Exploring the Relationship of Urban Density and Human Security: Studying Asian Megacities of Mumbai,Ahmedabad and Tokyo(Dissertation_全文)

AUTHOR(S):

Sukanya Misra

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アジア・メガシティのムンバイ，アーメダバード，東京を対象として

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By,

Sukanya Misra

Under the Guidance of,
Prof. Teruyuki Monnai

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Department of Architecture and Architectural Engineering,
Graduate School of Engineering,
Kyoto University

For Ma and Baba;

~ You are my idols, my teachers and the wind beneath my wings ~

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Abbreviations

AC	Amenity Crowding
AMC	Ahmedabad Municipal Corporation
AUDA	Ahmedabad Urban Development Authority
BKC	Bandra Kurla Complex
BMC	Brihanmumbai Municipal Corporation
BUA	Built Up Area
CBD	Central Business District
CBO	Community Based Organizations
CDP	City Development Plan
DI	Development Indicators
DM	Density Measures
DRP	Dharavi Redevelopment Plan
FAR	Floor Area Ratio
FSI	Floor Space Index
GIDC	Gujarat Industrial Development Corporation
GNP	Gross National Product
HC	Home Crowding
HDI	Human Development Index
HDR	Human Development Report
JC	Job Crowding
LPCD	Litres Per Capita per Day
LR	Land Readjustment
MCGM	Municipal Corporation of Greater Mumbai
MDG	Millennium Development Goals
MHT	Mahila Housing Trust
MMRDA	Mumbai Metropolitan Region Development Authority
NGO	Non – Governmental Organization
NIUA	National Institute of Urban Affairs, India
NSDF	National Slum Dwellers Federation
OECD	Organisation for Economic Co-operation and Development

PC	Park Crowding
PF	Plot Factor
SC	Street Crowding
SEWA	Self Employed Women's Association
SNP	Slum Networking Programme
TDR	Transferable Development Rights
TMG	Tokyo Metropolitan Government
UN	United Nations
UNDP	United Nations Development Programme
UNFPA	United Nations Population Fund
WPR	Workers Participation Rate

Executive Summary

1. Background of Research

Global Urbanization trends show that the world we live in today is increasingly becoming urbanized with the majority of the world population residing in urban areas. A majority of the future world population will be citizens of urban areas in developing countries with Asia housing the largest share. It is therefore important to investigate the issues related to urbanization in the cities of Asia, specifically in those of developing countries.

In developing countries, urban centres grow as they increasingly become larger centres of production causing huge rural – urban migration without similar growth or diffusion into the hinterland (Sassen, 2005; Thornley and Rydin, 2002; Castells and Borja, 1996). Apart from the growing economic gap of urban-rural populations and also between the high income and low income urban inhabitants, issues of insufficient infrastructure and housing, social exclusion, gentrification, rising levels of crime and pollution, and frequent spread of diseases are often seen especially in the large megacities of the developing economies, which are ill equipped financially and policy-wise, to support the tremendous and rapid growth of urban population (Carmona, 2000; Burgess, 2000). The major issues associated with urbanization in developing countries are, growing economic gap, insufficient infrastructure, gentrification and growing housing cost, social exclusion, crime, pollution, disease and obsolete urban policies.

In light of such alarming issues affecting a growing majority of human population, it is important to reconsider the role of cities, and the way in which they affect people's lives. Cities are a multi-layered superimposition of dynamic systems in which people live, work, play and interact with their environment, both animate and inanimate, for the material, sentimental and spiritual pursuits of the individual and the collective. If a city cannot provide an appropriate system of functions and resources to afford its inhabitants to freely pursue their individual and collective goals, then there will be a clamour for the limited supply and crowding of residences, employment, and recreation, interrupting the organized occupation of land, structure of infrastructure, and legislation (Brennan and Richardson, 1989; Prud'home, 1996; Buehler, 2003). This research explores the capability of urban residents to live freely in a way of their choosing, enabled by the urban systems which shape their lives. In doing so, this research aims to propose a planning approach based on increasing human security of all socio-economic groups and a methodology to identify the specific urban systems associated with lower human security in each city.

2. Research objectives

The main objectives of this research are outlined below.

1. To formulate indicators to measure levels of Urban Density (Density Measures).
2. To formulate measures for Urban Development (Development Indicators)
3. To apply these measures to cities and adapt them according to data availability and the historical, economic, political and social context of the city.
4. To derive substantial relationships from ward wise comparisons between levels of Human Security and measures of Urban Density and identify the elements of crowding in each city.
5. To identify ward clusters of differential human security levels.
6. To derive optimum function to model urban density according to human security to serve as a tool for urban planning.

3. Research hypothesis

The extent to which a city's resources and systems are consumed by its inhabitants, are understood as various levels of urban density existing within the urban system. Quantitative measures to express the density of occupation of urban land, density of built up structures, density of consumption of infrastructure and amenities, density of employment opportunities, and density of the use of public transportation have been formulated and collectively termed as the Density Measures (henceforth DM).

Various socio-economic groups have different relationships with the DM as access to physical, social and economic resources, allow individuals varying degrees of control over their environment. Lack of control translates into insecurity, which is a situation in which an individual is deprived of the capability to pursue a decent standard of life as deemed fit by them, due to factors such as poverty, gender inequality, social suppression, lack of privacy, physical disability, crime and violence. Collectively, Human Security is therefore defined as "Freedom from Fear, Freedom from Want, and Freedom to live with Dignity" and it is affected by many factors one of which is crowding of urban density measures which limits the "beings" and "havings" of capabilities. Insecurity manifests itself in various ways and can be measured using the Development Indicators (henceforth DI) formulated to quantitatively measure the level of economic equity, health, education, social equity and good governance experienced by people residing in different areas of the city.

Theoretically, the relationship between DM and DI are discussed by the Density Intensity theory of Crowding and the Capability Approach of understanding Human Security. The DMs represent the fundamental elements of the city which are susceptible to crowding. Various relations exist within urban areas such as land rents, building regulations, special planning areas, etc. The people of different socio economic classes are affected by these relations in different ways and are afforded varying levels of access to the elements represented by the DM. The place and manner in which each urban household chooses to live and work, formed as a result of the interaction between their socio-economic background and the element and relations of the city, are the systems of the city. These systems reflect the degrees of capabilities of individuals to lead a life of their choosing and hence reflect their human security, as measured by the DIs. The socio-economic backgrounds of the people and the limitations posed by them are the essential causes of human security. In the absence of any such limitations in capability, the city's elements and systems will not have a differential effect however, in the case where any socio-economic stresses are present; they will be further intensified by crowding.

4. Research Methodology

The **first step** of the methodology involves collecting ward level data and applying it suitably to formulate the DI and DM for the city being analysed. In **step two**, a multiple regression analysis is done following scatter plots and Pearson's correlation analysis, to understand the DMs that affect DI positively and those that pose as a limitation. The **third step** is a cluster analysis using Ward's Method and DI as the clustering variable, to plot the spatial pattern of levels of DI clusters present in the city, which represents the spatial distribution of social areas. The results from steps 2 and 3 help in identifying the crowding situations in each city, and the DM causing it. In the **fourth step**, literature reading is done to support the quantitative analysis and to understand the existing land use characteristics and evolution of the spatial, social, political and economic systems of the city. The **fifth step** is a micro-level analysis done through on – site investigation and mesh analysis. The analysis done at various scales and using various types of data is cross referenced to identify features in each city corresponding to crowding and thus urban typologies representing human insecurity is identified in each city. Together with the background literature of the city's economic, political, social and environmental systems, this methodology aims to add the dimension of 'density' in reading a city and 'crowding' in assessing its development goals for reducing the gap between its social areas.

Mumbai, Ahmedabad and Tokyo have been selected because, Mumbai and Ahmedabad present differences in scale and urban character while retaining a similar socio-economic structure

whereas Tokyo diverges completely in terms of socio-economic character, but has a similar scale of population as compared to Mumbai. A test across many divergent factors is hoped to bring in universality in testing the hypothesis, and pose interesting situations which can then be used to amend the initial hypothesis to make it robust.

5. Key Findings

Data mining techniques reveal that certain corollaries between the DM and DI data does exist and a regression equation for predicting ward-wise DI using respective DM values was found. Since this prediction is possible across the wards with little error, it is reasonably assumed that DI and DM are intrinsically linked in all three cities, although the nature of this relationship differs from one city to another as expected from places of different evolutionary paths.

The regression equations for Mumbai and Ahmedabad were very similar. In both these cities, Amenity and Autonomy have a positive linear relationship with DI. This is quite natural because the residents of both these cities share the same problems that are usually seen in cities of developing countries. In the absence of adequate provision of the very basic human needs such as water, sanitation and stable employment, the survival of many individuals depend on the access to such factors and the availability of which give a high level of security to respective individuals while causing distress to those not in possession of the same. The struggle to have access to such basic necessities therefore takes central place in such people's lives, hence depriving them of striving for and achieving higher goals of education, participation in local governance, and equality in slums in the worst wards of Mumbai. Also, although the unemployed percentage and physical density does increase linearly from the best cluster to the worst in Ahmedabad, the difference between the two extremes is very small as compared to Mumbai, because the percentage of slum dwellers in Ahmedabad is much smaller as compared to Mumbai.

The regression analysis of Tokyo revealed that physical density and autonomy had a positive relationship with DI whereas intensity and frequency had a negative relationship with DI. High cost of housing is a major problem in Tokyo which has forced a majority of the working population to find residences at very far distances from their working places within the city. This has caused the floating population of the city to be very high. Also, the high land price has caused high intensity development and the depletion of open areas. Following the land rent theory, commercial and office uses occupy the central city, with very low residential density, high floating daytime density and high building intensity, which lead to high pollution during

office hours and high crime after office hours. The areas which have high residential density with sufficient employment in the vicinity do not suffer from the aforementioned problems and are therefore the areas of high DI.

The results of the mesh analysis show that lower built up percentages and higher number of floors correspond to better housing grades across all three wards. So, higher and middle income groups residences correspond to mid to high rise buildings with less ground coverage and more open space area whereas slums have very little open space and are mostly low rise. This pattern is consistent in all the areas analysed regardless of the DI cluster to which they belong.

6. Conclusion and Way Forward

The relationships between Urban Density and Human Security of urban inhabitants have been explored using a 5 step methodology, spanning macro and micro spatial scales as well as quantitative and qualitative data analysis. Each of these 5 steps has useful applications in the plan formulation activities of the concerned city. The steps 1 and 2 of the methodology involving the formulation of DM and DI and the regression of DI on DM has resulted in the identification of the DMs that are associated positively and negatively with DI in each city. This has proved that a relationship between DM and DI does exist as hypothesized and also identified the DMs that are crowded in the low DI areas in the study areas. Specific sector based planning interventions can therefore be framed based on improving the levels of these overcrowded elements. The step 3 of the methodology involving the cluster analysis has helped to identify the ward clusters in each city that have the lowest human security, as well as the specific DI levels of each ward. This can be effectively applied to framing structured planning policies catering specifically to the DI levels of each of the 5 different clusters. The 4^{th} step in the methodology involves qualitative analysis of urban areas and is an iterative process that has not been discussed in detail in this paper. The 5^{th} and final step is the micro-level mesh analysis which, applied to three wards in Mumbai, has definitively supported the results of the aforementioned regression analysis in establishing that a relationship between the DM and DI does exist. It has investigated the relationship between intensity datasets and housing grade and successfully identified typical urban typologies that correspond to a range of different socio-economic levels. The identification of these urban typologies can find wide application in the assessment of quality of urban areas and neighbourhood level planning initiatives through a framework targeted at improving DM and DI levels.

Chapter 1:

I N T R O D U C T I O N

"When cities were first founded, an old Egyptian scribe tells us, the mission of the founder was to 'put gods in their shrines.' The task of the coming city is not essentially different: its mission is to put the highest concerns of man at the center of all his activities."

– Lewis Mumford, writer, The City in History (1961)

1.1 Overview

Cities are a multi-layered superimposition of dynamic systems in which people live, work, play and interact with their environment, both animate and inanimate, for the material, sentimental and spiritual pursuits of the individual and the collective (Corbusier, 1943; Mumford, 1937). Increasing diversity of the social and economic profiles of urban inhabitants within a concentrated urban area increases the complexity of the multi-layered urban system and challenges its ability to provide suitable premises and places required to serve such diverse communities. An increased concentration of people with wide socio-economic variation, if suitably served can bring versatility, creativity and opportunity for the development of each individual and even greater benefit for the agglomeration (Knudsen *et al*., 2007; Sassen, 1994; Castells and Hall, 1994). However, if a city cannot provide an appropriate system of functions and resources to afford its inhabitants to freely pursue their individual and collective goals, then there will be a clamour for the limited supply and crowding of residences, employment, and recreation, interrupting the organized occupation of land, structure of infrastructure, and legislation (Brennan and Richardson, 1989; Prud'home, 1996; Buehler, 2003). This research explores the capability of urban residents to live freely in a way of their choosing enabled by the urban systems which shape their lives.

The degree of access to urban land by urban inhabitants is traditionally expressed as urban density. This research extends this to all urban resources and systems, the degrees of access to which are assessed as multiple layers of urban density. These layers of various urban densities exist in varying quantities in different areas in each city and may be sufficient or insufficient in proportion to the population that is affected by it. Insufficiency of the urban resources and systems sustaining urban activities, causes crowding. This limits the capability of the urban residents of those areas and has a domino effect on the social and economic aspects of their lives, thus diminishing their human security. A quantitative measurement of the urban density layers in various cities is done, accompanied by the measurement of the human security of urban residents in the corresponding areas. The elements of crowding are identified by analysing the relationship between human security and urban density. An analysis to categorize the cities into zones of varying human security is also done and deeper study of these variations is carried out through field study, spot survey and literature reading.

This research proposes a methodological framework which may be applied to any city to identify its crowding characteristics, find areas of high inequality and poor human security and use density of urban systems as an important indicator in reading the city.

1.2 Background

1.2.1 Global Trends of Urbanization

Over the next 15 years, the center of gravity of the urban world will move south and, even more decisively, east.

- Mc Kinsey Global Institute Report, Urban world: Mapping the economic power of cities

It has been stated that 60% of the population of the world will be living in urban areas by 2030 (UNFPA, 2011). The general trend of urbanization shows that the population growth rate of the cities of developed countries of Europe and North America is decreasing. On the other hand, the population growth rate of cities of developing countries, especially those in Asia and Africa, are increasing exponentially and will continue to do so and by 2050, around 70% of the world's urban population will be living in Asia and Sub-Saharan Africa (Fig. 1.1), most of which will be in the developing countries.

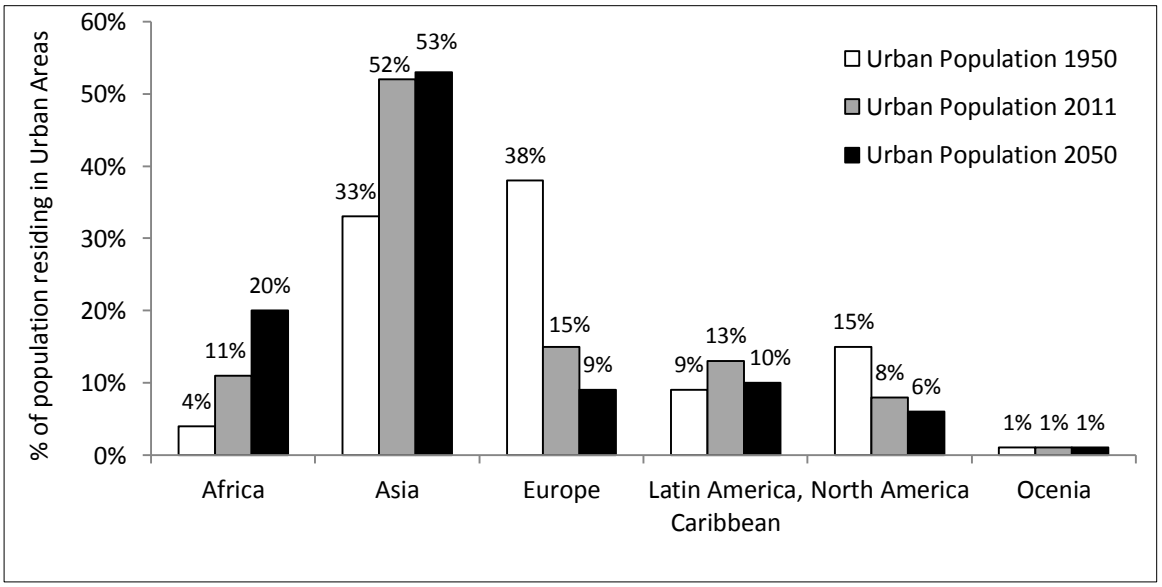

Fig. 1. 1 Global Urbanization Trends
Source: World Urbanization Prospects, 2011 Edition, United Nations, Department of Economic and Social Affairs, Population Division.

Another urbanization trend seen is the growth of the second-tier cities. It is a common misconception that the rapid urbanization of the world in the past few decades has been driven by the growth of the megacities (cities with population greater than 10 million) of the world. Although they have been responsible for globalization and have enjoyed increased influence over very large areas, the growth in their population has on average been similar to that of their host economies (McKinsey, 2011). This is perhaps explained by the theory that urban growth follows an attenuated S-shaped curve (Davis, 1965) with very slow growth rate initially, which shoots up dramatically in the centre of the "S" and the levels off or gradually diminishes,

illustrated by the negative growth potentials of many American cities as compared to the positive growth trends of newer cities in China and India. This is also exemplified by the growth trends of second-tier cities in Asia which are currently experiencing exponential growth rates in stark contrast to the Asian megacities. Seven out of the ten largest megacities of the world are in Asia however the growth rates of these cities have declined and are comparatively slower that the growth of second-tier cities (Mc Kinsey, 2011; Bhagat, 2005). The growth rates of a few selected Indian second-tier cities as compared to Indian mega-cities are illustrated in Fig. 1.2.

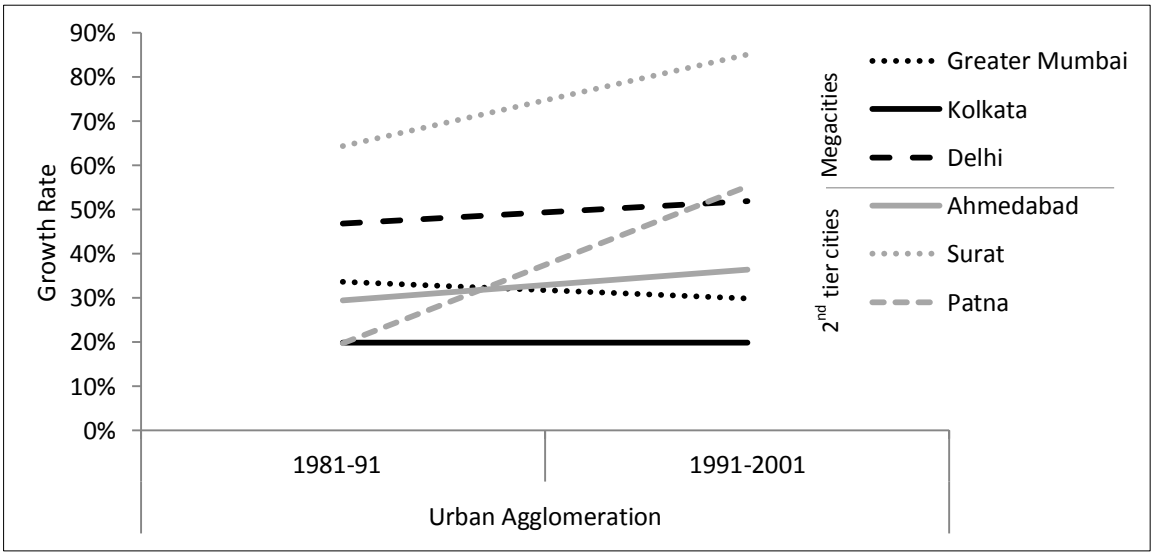

Fig. 1. 2 Growth Rates of Indian Cities
Graph generated using data from Bhagat, 2005, Urban Growth by City and Town Size in India

Global Urbanization trends show that the world we live in today is increasingly becoming urbanized with the majority of the world population residing in urban areas. A majority of the future world population will be citizens of urban areas in developing countries with Asia housing the largest share. It is therefore important to investigate the issues related to urbanization in the cities of Asia, specifically in those of developing countries. Furthermore, although studying the current issues faced by residents of megacities need to be considered, the second-tier cities also hold an important place in the study as they hold the scope for amendments to the path of their urbanization.

1.2.2 Issues of Urbanization in Developing Countries

The wave of urbanization seen in developing countries is very different from the urbanization in developed countries where urbanization is generally associated with dramatic increases in the quality of life. In developing countries, urban centres grow as they increasingly become larger centres of production causing huge rural – urban migration without similar growth or diffusion into the hinterland (Sassen, 2005; Thornley and Rydin, 2002; Castells and

Borja, 1996). As the American and European megacities are making the shift from their functions as manufacturing economies to centres of managing information, global financial services and co-ordination, and control of manufacturing bases in third-world cities (Sassen, 2005; Sassen, 1994; Castells and Hall, 1994; Frobel *et al*., 1980), the urban areas in developing countries, especially those in Asia, are emerging as the new centres of manufacturing and producer-service functions (Schaeffer and Mack, 1997; Savage and Warde, 1993; Kasarda, 1990; Frobel *et al*., 1977). This is bringing in huge financial investments to fuel the growth of urbanization in developing countries creating millions of new jobs in these urban areas. This can provide 'enhanced opportunity for millions of people', and 'refuges from a stifling, restrictive rural life' that may no longer be economically sustainable (Seabrook, 1996, p.5). However, this growth is a double edged sword as it is also increasing the economic divide between the rich and poor class, urban and rural regions, and pushing a large part of developing nations into deeper levels of poverty. Apart from the growing economic gap, issues of insufficient infrastructure and housing, social exclusion, gentrification, rising levels of crime and pollution, and frequent spread of diseases are often seen especially in the large megacities of the developing economies, which are ill equipped financially and policy-wise, to support the tremendous and rapid growth of urban population (Carmona, 2000; Burgess, 2000). The major issues associated with urbanization in megacities of developing countries are discussed below.

1. Growing economic gap, inequality, poverty

Large multinational companies often set up bases in the city centres of megacities in developing nations. A large number of jobs are created either due to the presence of a specific skill set (such as outsourcing Information Technology services to Indian cities) or due to the availability of cheap labour. Small parts of the local population who are involved in the management of such industries stand to gain whereas a large proportion of the labour is exploited (Carmona, 2000:58). A growing marginal economy is also created which further widens this gap and increases occupational vulnerability (Sassen, 2001:335).

2. Insufficient infrastructure

The growth of the city is largely funded by the private sector investments which are only directed at the growth of industries and profitable residential enclaves. The public sector is unable to keep up with this growth in terms of updating superannuated infrastructure and building new and modern systems responsive to the current needs. The exponential rise in demand for affordable housing is also not met by the public sector.

The rapid growth in population exceeds the capacity of existing medical and educational facilities. Private enterprises of these facilities are often unaffordable for a majority of the

population which limits their capability to access healthcare and education, delegating future generations into poverty traps, hence increasing inequality.

3. Gentrification, Growing housing cost, slums

With new hubs of activity crowding the city centres, the land prices of these areas increase. This encourages the construction of plush multi-storeyed gated communities for housing the rich while the poor are exported further and further away from the city centre. The increased travel cost and time, coupled with the scarcity of jobs at urban fringes encourages the formation of slums near the city centre on marginal land illegally (Fig. 1.3). Small businesses also suffer as they are unable to survive the cost inflation, which gives rise to unemployment and a growing informal sector.

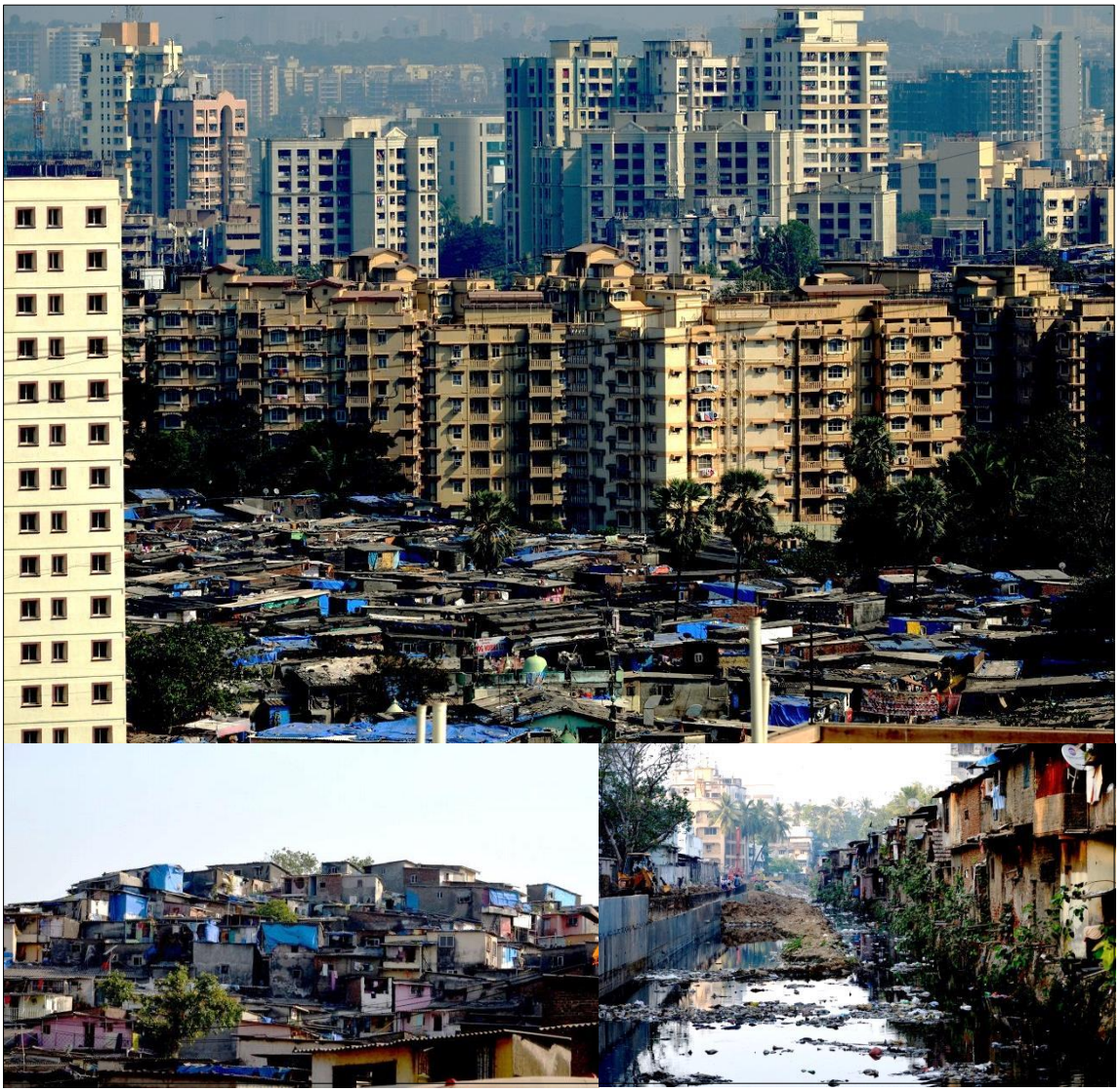

Fig. 1. 3 Slums on marginal land in Mumbai

4. Social exclusion

In cities where the spatial distribution of socio-economic groups is a function of economic segregation, the poor have no place to go. Forced to make a choice between rural poverty and urban opportunity, a large exodus of previously agrarian labour class lacking any specialized urban industry skill-sets, moves to urban areas. Faced with another choice in the urban area, between unsanitary living conditions in slums near areas of informal jobs or better living conditions in areas of livelihood uncertainty, the migratory population are scattered based on wherever they can find a way to feed and clothe themselves. This breaks all previous social bonds. Furthermore, the uncertainty of subsistence, coupled with the impermanence of the illegal squatters, inhibits the development of strong social ties, even with similar socio-economic classes. Furthermore, there is a growing social divide between the low wages of unskilled workforce or unemployed population, and the salaries of the high skilled specialists, which fragments the city (Sassen, 2001:335).

5. Crime

A rise in organized crime is often seen with the growth of megacities. These organizations garner immense power and resources by capturing the lucrative land markets, construction industry, other industrial sectors and international trade, by dealing with or extorting from the eminent city figures. The growth of the megacities is often accompanied by the rich getting richer and the poor getting poorer as discussed earlier. A section of the society therefore enjoys material comforts and boasts of wealth that would have been unimaginable a few decades earlier. At the other end of the economic spectrum, poverty traps prevent the poor from ever rising above the poverty line. Faced with hopelessness, many join the organized crime circuits to earn a living as well as to enjoy basic amenities and security that the governance in unable to provide. This further strengthens the criminal networks often making them parallel governing bodies of the city (Mehta, 2004).

6. Pollution and Disease

The intensification of inner city areas and densification of urban neighbourhoods, propagated for increased environmental efficiency in cities of developed countries, does not hold true in developing countries. The rapid increase in users of the CBD causes an increase in the road traffic near the city centre, further encouraged by the increase in affluence experienced by a portion of the population, which increases personal automobile ownership. This causes high levels of air pollution in inner city areas. The city planning division usually responds to traffic congestion by building new roads and highways to manage the increase in vehicular traffic, however, in the absence of proper linkages, these developments cause huge

traffic bottlenecks which reduce the speed of increased traffic flow contributing to air and noise pollution.

The increased density also facilitates the spread of diseases (Fig. 1.4). Slums have people living in extremely close quarters in very unsanitary conditions. These are breeding grounds for diseases. Furthermore, the increased density of public transport usage also increases human contact and facilitates the spread of diseases.

Open areas become increasingly scarce as urban greens are developed into profit generating centres. The remaining parks and open spaces get crowded due to an excess of people dependent on them. The lungs of the city are lost which degrades the air quality, creates urban heat islands and constricts natural drainage causing floods. Furthermore, most urbanites have no place for physical activity and interaction with nature which is a serious danger to health and well-being.

Fig. 1. 4 Crowded dock areas, Sassoon Dock, Mumbai

7. Obsolete Urban policies ill equipped to manage megacities and Ineffective Governance

With all the issues discussed in this section, the onus lies on the metropolitan government to manage the growth of the megacity and address the problems with an effective and egalitarian approach. However, the governance machinery often falls short due to the extremely large numbers of people, the exponential growth rates, and the ever rising complexities.

Central city densities tend to be much higher in developing countries as compared to urban areas in developed countries (Jones, 2000:38) due to a wide range of reasons. Proponents of the Compact City theory maintain that compaction gives rise to greater efficiency in the use of economic, social, physical and environmental resources. This holds true in the developed world where the country dweller relies less on public transport and more on the personal automobile. Additionally, the per capita cost of provision of physical infrastructure and social amenities is greater in the low density areas as compared to dense city cores. However, for developing countries such as India, this theory does not necessarily hold true.

High degrees of compaction in cities of developing countries are not the result of stringent development guidelines and a vision for sustainability. In megacities of developing countries, compaction is due to spontaneous and chaotic large rural-urban migration increasing the concentration within restricted urban areas, low family income due to which large families reside in small tenements and the increase in land rent value limiting low and middle income families into highly packed dwelling units. These are some factors which increase the physical density of the city. Additionally, all the issues of urbanization that have been discussed are also related to the increased density of certain city resources, amenities, or functions. The high demand for a very limited number of jobs for example, creates a high density of people competing for each employment position. Whether it is in the highly skilled technical sector, service sector, manufacturing sector, or for informal jobs, the urban growth outpaces the supply of jobs. Similarly, the physical infrastructure and social amenities present are not able to serve the urban population efficiently as the density of people dependent of them far outnumbers their intended capacity. A similar tendency is seen for transport infrastructure also. One of the main concerns of the compact city theorists is the increase in vehicular traffic that accompanies urban growth in developed countries. The urban populations of developing countries however do not follow this trend. Since the large scale rural-urban migrants are financially weak, vehicular affordability does not accompany urbanization. The use of public transport systems however does increase which causes immense amounts of crowding on the routes serving the CBD.

The metropolitan governments in developing countries attempt various strategies to solve these problems of increasing density for jobs, infrastructure, urban housing, urban land, and transportation. One common strategy is to make the cities poly-nucleated so as to distribute the population more evenly over a wide area hence making it easier to manage the city. This strategy is common in cities in India and involves either the merger of smaller cities with the megacity as in the case of the Mumbai Metropolitan region, or, less commonly, the

systematic broadening of the urban boundary and delegating more rural land for urban uses. Metropolitan governments and planning agencies also struggle to keep up with the pace of urbanization in order to build up the capacity of resources and systems especially due to the ever changing density dynamics where previously rural areas become highly crowded and due to a huge floating density that increases the daytime density of the CBD by as much as six time of the night time density in Mumbai.

The central reason for the failure in governance is therefore the inability to measure and take accurate stock of the existing dynamic situation. The crowding for amenities, urban space, jobs and infrastructure that have been discussed here, can be effectively dealt with if the magnitude of the crowding, spatial distribution of varying magnitudes, and the resultant issues it causes in the lives of urban residents can be assessed.

1.3 Aim of the Research

This research aims to construct a methodology using which the various layers of density of an urban area can be measured in order to understand the components of crowding in the system. Furthermore, this research strives to understand how this crowding limits the capacity of urban inhabitants from having the freedom to live according to their aspirations. This capability deprivation, caused by a multitude of factors and further aggravated by crowding, is a loss of human security of urban residents. This research therefore also aims to find a way to quantitatively measure the human security of urban residents so that an objective comparison of people residing in different density areas can be done, to understand the relationship between crowding and human security in a clearer way. The proposed methodology can help in policy formulation and planning, by adding the dimension of urban density and crowding, in reading and understanding the city.

1.4 Research Terminology

1.4.1 Definition of Urban Density

Urban Density is commonly defined as the population density of an urban area and expressed as people per sq. km or households per sq. km. It is measured as Gross Density (any density figure for a given area of land that includes uses not necessarily directly relevant to the figure ; usually roads and other transport infrastructure) or Net Density (a density figure for a given area of land that excludes land not directly related to the figure).

This definition is not capable of expressing or explaining the wide range of influences that various types of Urban Density has on many facets and functions of the urban system. This

research therefore will aim to understand Urban Density more comprehensibly to include expressions to measure the density of urban resources and system in addition to that of occupation of urban land (as expressed by population density).

1.4.2 Definition of Human Security

The meaning of the concept of Human Security interpreted in this research equates insecurity to capability deprivation as discussed by Amartya Sen in "Development as Freedom". The ability of being certain things and having certain things, both material and abstract, define the freedoms from want and fear, and that to live life in a dignified way, which are the central aspects of having human security. The methodology proposed in this research offers Development Indicators (DI) to measure the degree of relative freedoms of the inhabitants to make choices regarding their economic and social situation and understanding Human Security of city dwellers at the ward level, by considering the local context and intra city inequalities.

1.5 Research Objectives

The main objectives of this research are outlined below. An explanation about how each of them will be addressed is detailed in the next section about the research methodology.

1. To formulate indicators to measure levels of Urban Density (Density Measures).
2. To formulate measures for Urban Development (Development Indicators)
3. To apply these measures to cities and adapt them according to data availability and the historical, economic, political and social context of the city.
4. To derive substantial relationships from ward wise comparisons between levels of Human Security and measures of Urban Density and identify the elements of crowding in each city.
5. To identify ward clusters of differential human security levels.
6. To derive optimum function to model urban density according to human security to serve as a tool for urban planning.

1.6 Research Structure and Methodology

The research follows three main sections. In the first section, studies of human security indicators and urban density measures are formulated through extensive literature reading about density, urban form, human needs, human security and development. This is discussed in detail in chapters 2 and 3.

The second section involves the adaptation and application of the development indicators and density measures to the case study cities by gathering available ward level data from those cities. The case study cities selected are, Mumbai, Ahmedabad and Tokyo. Mumbai is a megacity in the developing economy of India and has all the issues that accompany large-scale urbanization in developing countries. Ahmedabad is a second-tier city in India showing rapid urbanization as discussed previously in this chapter. It is very different from Mumbai in terms of scale of population, urban complexity and the severity of urban issues. However, if not planned properly, its current exponential growth can transform it into a similar case as Mumbai very soon. Tokyo is very similar to Mumbai in terms of the scale of population, density, and the size of the urban area. However, the socio-economic backgrounds of these two cities are very different. Furthermore, also very dense, Tokyo is not suffering as much as Mumbai and the human security of the people of Tokyo, is high, which is why this city is studied. The methodology proposed in this research is applied on all these cities as a test across many divergent factors will ensure the conclusions drawn are not biased. The methodology proposed involves a macro-level statistical analysis of the relationship between density measures and development indicators to understand the elements of crowding in each case study city, using ward level data. Statistical analysis to find different clusters of varied human security in each city is also done at this stage. The macro-level analysis using ward-wise data is followed by a micro-level analysis using data gathered from spot surveys in Mumbai, to investigate if the trends noticed in the ward level still held true at the level of a grid mesh of 500 m x 500m. The proposed methodology involved five steps which are applied to the case study cities. The chapters 4, 5, 6, and 7 make up the second section of the research.

The third section is an intercity discussion about the various relationships found in each city and a look into the reasons for the crowding situation in each city. Furthermore, the various layers of density are modelled using various mathematical density gradient models to find the most optimum density functions in the case of each city. This helps to determine how policies should target each region within each city, based on differential levels of human security and therefore uplift the lives of all urban residents by reducing capability deprivation and social exclusion. This section is detailed in chapter 8 and ends with the conclusions in chapter 9, with a look at ways in which it could be continued in the future.

The three step structure discussed above is illustrated in Fig. 1.5. The objectives stated in the previous section are also included to clarify at which stage each is expected to be achieved.

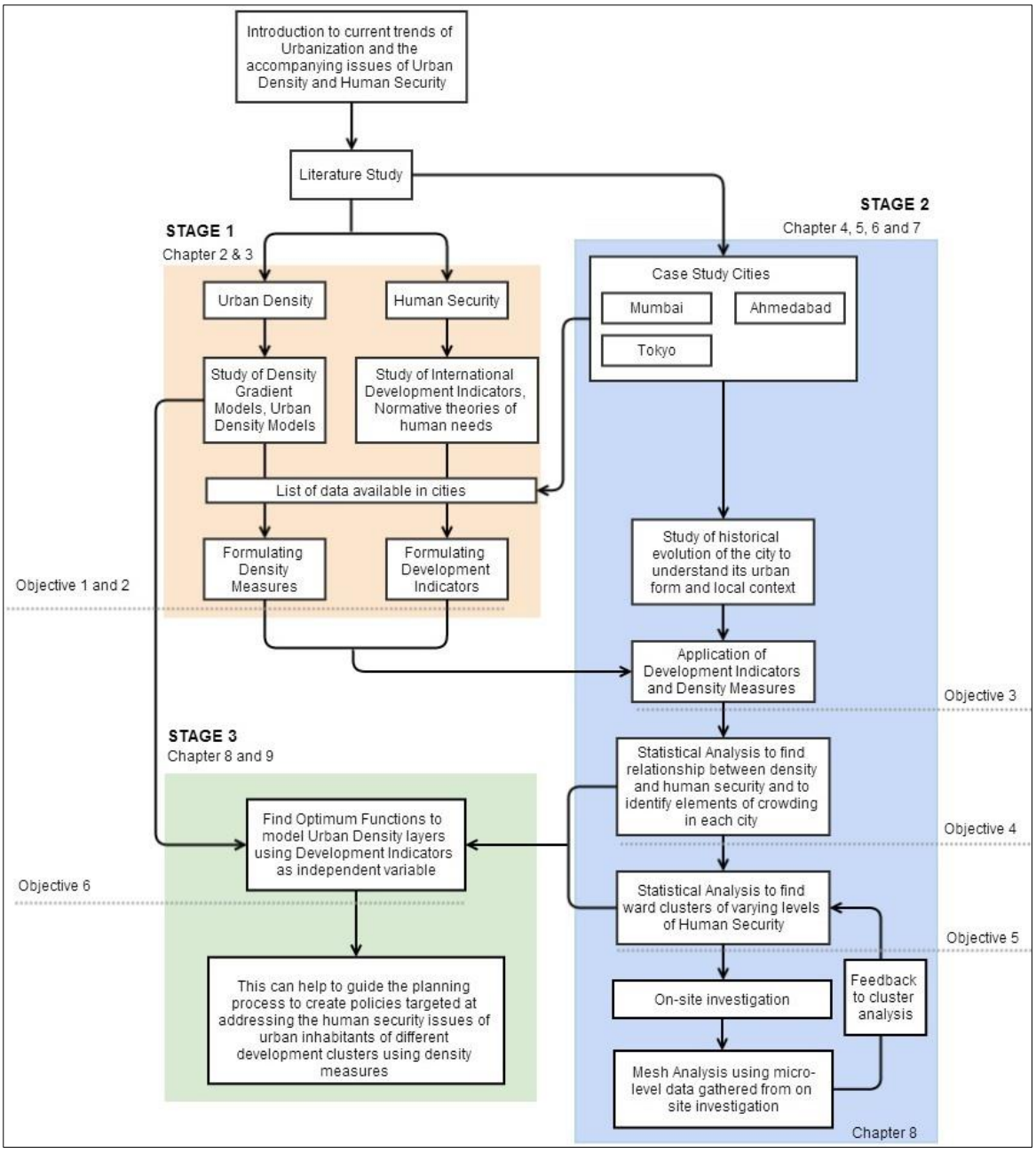

Fig. 1. 5 Research Methodology

1.7 Scope and Limitations

A methodology for the analysis of the spatial distribution of varying levels of human security clusters in a city is proposed in this research. This will help to identify; easily and with limited data, the areas in a city that need the most urgent planning interventions for improving human security. A methodology for identifying the crowded density measures in each city is also proposed. This helps to understand which density measures need to be increased or decreased in order to achieve better human security. Using the two aforementioned methods one can identify the varying levels of human security in different areas in a city and identify the trends that the density measures must follow in these areas for greater equality in the city.

The various analysis techniques which form the methodology are suitable for identifying human security levels and crowded density measures in a specific point in time. All of the analyses are synchronic and allow for planning decisions to be taken based on the existing issues identified though the methodology. The effectiveness of this methodology therefore depends on the accuracy of the data being used and how recent that data is. The results from one set of data cannot be projected over time, as the multiple indicators involved change dynamically in modern urban areas and are difficult to predict accurately. This methodology should therefore be applied periodically to appraise the situation of human security of urban inhabitants and maintain a planning approach centred on it.

1.8 Conclusion

This chapter outlines the reasons for doing this research by identifying the issues of urbanization that the majority of the world's population is facing today and will increasingly do so in the future. A need to identify the various layers of urban density in analysing cities has been established. Furthermore, the need to plan cities for allowing the maximum capability and freedom of each individual has also been discussed. Since crowding is an issue that aggravates capability deprivation, the need to find a methodology to study the relationships between the two and to identify areas of low human security in cities, has been stated as the aim of this research. Case studies to be used and test this methodology have been sighted and a structure for achieving each of the objectives listed has been proposed.

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Chapter 2:

METHODOLOGY FOR FORMULATING DEVELOPMENT INDICATORS TO MEASURE HUMAN SECURITY

"The test of a progressive policy is not private but public, not just rising income and consumption for individuals, but widening the opportunities and what Amartya Sen calls the 'capabilities' of all through collective action."

— Eric J. Hobsbawm

2.1 What is Human Security?

Security is the protection that separates the assets from the threats, such as the security provided by the roof that protects residents from the threats of the harsh climate outside. Human Security is defined as the state of having freedom from want, freedom from fear and freedom to live a life of dignity and equal opportunity. In this definition, the asset is each person residing in or using the urban area with their individual aspirations, beliefs, and goals. The threats are agents that stand to inhibit such individual aspirations or impose certain conditions. These may vary from social discriminations of class, gender, age, etc., to administrative impositions and much more. Insecurity is therefore the inability of a person to live a life of their choice; being forced by their circumstance and chance, rather than being able to live by their individuality (Karl Marx). Thus the capability to live a life of individual choice imparts Human Security.

2.2 A brief History of Human Security and the United Nations

The present concept of human security has evolved since 1991 after the end of the cold war when various factors were challenging the traditional notions of security and development of nations. The rapid globalization, reduced threat of nuclear war between super powers, spread of democracy and international human rights laws allowed for a new view on security to be considered. Additionally, new threats to national security emerging from internal conflicts, disease, climate change effects and obsolete development models forced a new look at the established notions of security and development which was previously focused on military power of nations. Hence, the concept of human security shifted focus from safeguarding against external dangers, to strengthening growth within the country. The United Nations Universal Declaration of Human Rights was adopted in 1948 which was largely influenced by the “Four Freedoms” articulated by United states President Franklin D. Roosevelt in 1941 and adopted during World War II. The four freedoms, namely, freedom of speech, freedom of worship, freedom from want and freedom from fear were an important precursor to the definition of Human Security in the United Nations Development Programme's Human Development Report 1994.

The United Nations Development Programme's Human Development Report 1994 is an important document in the field of human security, which famously argued that ensuring "freedom from want" and "freedom from fear" for all persons is the best path to tackle the problem of global insecurity. It stated that the concept has “for too long been interpreted narrowly: as security of territory from external aggression, or as protection of national interests

in foreign policy, or as global security from a nuclear holocaust. It has been related more to nation states than to people." It went on to define Human Security as the sum of seven core elements to be ensured for individuals and communities which are; economic security, food security, health security, environmental security, personal security, community security and political security.

2.3 Evaluating Human Security

There have been many concepts that have tried to evaluate the lives of people. These can be classified into three main categories; the commodity based evaluation, the utility based evaluation, and the capability based evaluation.

2.3.1 Commodity based evaluation of Human Security

The commodity based evaluation focuses on the means available to an individual or community for satisfying their developmental needs. The measure of Gross National Product (GNP) per capita is a popular example of this evaluation system. It assumes that nations of high GNP per capita have a high level of economic achievement per person which they can use to fulfil all of their needs, and therefore high GNP per capita directly indicates a good standard of living. This has however come under wide criticism (Sen, 1999) since the ability to convert means to ends varies from one society to another and is affected by a host of externalities. For example, countries such as Oman with a very high GNP of 6730 per capita, has an average life expectancy at birth of just 54 years (World Development Report, 1987). In contrast, Sri Lanka which has a per capita GNP of just 380 has an average life expectancy at birth of 70 years. Economic prosperity is often taken as the major goal of planning and policy making. However, considering that economic wellbeing cannot guarantee even the most basic human function of escaping pre-mature mortality, the preference of development and planning needs to be seriously reconsidered.

2.3.2 Utility based evaluation of Human Security

The utility based evaluation places value in the notion each individual has about their well-being. Common examples include the level of happiness or desire-fulfilment expressed as the subjective perspective of an individual. This has its merits in firstly, not being singularly focused on the means but also accounting for the ability to convert those means into ends deemed satisfactory to the individual. Secondly, it also understands that the aspirations of each individual or community varies from different economic aspirations to socio-cultural standards of well – being, physiological level of comfort, etc. and so, a certain individual might be happy in

a certain way of living while another individual might find it debilitating. This subjectivity however, is also one of the demerits of the utility based approach. In situations of long-standing deprivation, individuals often accept their fate and try to make the best of it, in the process of which they cut down personal desires to modest, more "realistic" proportions. So, even if a person is not adequately nourished, or minimally educated, they may still express satisfaction in their lives in which case their deprivation will go unnoticed and unaddressed in development planning.

2.3.3 Capability based evaluation of Human Security

The capability based approach to evaluating the wellbeing of a nation's people focusses on the ends that are achieved by its people. The capability to live by an individual's choice is reflected in their ability to achieve certain "Functionings" (Sen, 1990). Functionings may vary from the elementary to the complex such as escaping morbidity and mortality, being adequately nourished, undertaking useful movements, etc., to achieving self-respect, taking part in the life of the community, and appearing in public without shame (which is important in all cultures but whose commodity requirement varies as discussed by Adam Smith in 1776). The capability of a person is derived from the combination of functionings that he/she can achieve. These functionings are the basic elements of life and are a set of "doings and beings". For example, various functionings classified as "doings" are voting in an election, travelling, playing a sport, etc., whereas examples of "beings" include being well-nourished, being educated, being part of a supportive social network, etc. Since "functionings" as "doings and beings" are the basic elements of life, a combination of functionings creates a certain way of living. The freedom a person has in choosing various combinations of functionings to control and determine the way of their living, is their Capability. Human security is achieved by the protection and augmentation of human capabilities.

Capability can be measured by the level of ends achieved for example, achievement of literacy, adequate nourishment, comfortable shelter, etc. This concept has the merits of not judging by the means but accounting for the differences in capabilities to convert these means to suitable ends. Additionally, the subjectivity of individual perception found in the utility based approach is replaced by a measure of actual achievement. However, in order to assess whether or not the ends achieved by an individual are optimum, one would have to have a baseline with which all capabilities could be compared. For example, the number of years of average life expectancy at birth that is considered optimum would be needed to be known in order to assess the relative freedom of individuals. Such a baseline is fundamentally impossible since each society and community has different norms and standards with which individuals compare

their achievements to assess their relative freedoms. For example, achievement of literacy of up to secondary education may be of great value to an individual in a family of illiterate persons and afford them the freedom of pursuing a career of their dreams but the same achievement would be of no consequence to an individual who aspires for higher education.

Since a specific set of values cannot be prescribed to be representative of optimum capability for all societies and nations, it is important to measure the capabilities of sets of people in comparison to one another in order to identify the inequalities in the functioning achieved by individuals in the same society but living with different levels of human security. The capability deprivation of females for example, can be understood from such a measure where achievements such as work participation, life expectancy at birth, literacy, etc., are measured for both sexes.

2.4 Human Security and Development

Traditionally, economic growth was synonymous with development which in turn was taken as a benchmark for assessing people's wellbeing. However, during and after the period of rapid globalization after the cold war it was seen that the global population as a whole had gained very little from the economic gains of globalization. Thus questions were raised against the very tenets on which development practices were based. The concept of Human Development thus arose which argued that economic growth alone is insufficient to expand people's choice or capabilities, and areas such as health, education, technology, the environment, and employment should not be neglected. In addition, it also brought interest into studying and reducing the increasing gaps between people, causing insecurities leading to internal conflict and thus the failure of development.

Human security and human development are deeply interconnected. Human development strives to expand people's choices which in turn increase their human security. While human development focuses on growth with equity, human security checks who is left behind, deprived, and a slave to their circumstances rather than have freedom from fear, want and to live with dignity (Tadjbakhsh *et al.*, 2012).

Human development is generally a national measure although some human development assessments of smaller geographic systems have been done (HDR, Mumbai, 2009). The measure used to assess the level of human development of nations, called the Human Development Index uses national averages of life expectancy at birth, number of years of schooling, and gross national income per capita to calculate an index representative of the wellbeing of the nation's people. Although effective in the comparison of different countries, the HDI has no use in the

actual development planning and policy formulation mechanism in individual countries because of its mass aggregation.

This research strives for human development to be the motivation for planning practices at the urban area level. For this purpose, one would have to identify the inequality in the capability of different households living within the urban area. Measuring economic development of individual households can be a simple exercise of finding income and expenditure data. However, as discussed earlier, the commodities available do not govern the capabilities that can be achieved by individuals. The level of human development of individuals can therefore only be understood by measuring the functionings achieved by them.

Urban planners have for many years stressed upon the role of the urban area as a system of social functions. Lewis Mumford said that the city provides variety and differentiated opportunities for a common life, which define it and afford it greater appeal, and to achieve a sustainable urban area, the urban planning of the city should facilitate the many social functions and emphasize an organic relationship between people and their living spaces. The various networks that people create as a result of their daily activities in an urban area, defines the capabilities afforded to them by the physical, social, political and environmental systems of the city. The capabilities of various groups of people can therefore be studied by understanding the choices they make for living, working and recreation in the city. This is a measurement of the ends achieved by them utilizing the means provided to them by the urban system. Such a measurement would be an indicator of how developed the city is in proving and augmenting capabilities and thus ensuring human security. A measure of human security can therefore be an indicator for human development. A quantitative measurement of the human security levels of urban inhabitants as an indicator for taking stock of the level of existing development as well as for planning for the urban future would be an effective planning tool for human development. The formulation of such a measure termed the Development Indicator (henceforth DI) has been explored in this chapter.

2.5 Methodology for building measures of Human Security

2.5.1 Established Methods for the selection of Capabilities for measurement

The basis on which domains are selected for measuring human security can be understood in five categories (Sabina Alkire, 2007) as discussed:

1. **Existing Data or convention –** Using this basis, the capabilities to be measured are selected based mostly on convenience or a convention that is believed to hold true for the situation

being studied. Additionally, this may also be used when a limited amount of data is available and so only the capabilities represented by those datasets can be considered.

2. **Normative assumptions –** The capabilities are chosen based on informed knowledge of the researcher as well as conclusions drawn from conventions, social or psychological theory, to form implicit or explicit assumptions of what capabilities are valued or should be valued by the people.
3. **Public 'consensus' –** A list of dimensions legitimized by public consensus at the local, national or international level. The universal human rights, the Millennium Development Goals, and the Sphere project are examples of this category.
4. **Ongoing deliberative participatory process –** The focus here is on the ongoing debates by stakeholders that periodically question and discuss their views of essential capabilities.
5. **Empirical evidence regarding people's values –** Analysis of people's values done by experts, based on empirical data about preferences, behaviours, and conditions suitable for mental health and social benefit.

2.5.2 Constructing Development Indicators

The basis for selection of capabilities to be measured for the purpose of this research involved the first, second and third domains of selection explained in the previous section. The first, depending on existing data or convention played an important part because of two factors. Firstly, this research is interested in looking at the capabilities of people residing in cites. It is focused on the micro scale rather than the macro-scopic nature of the data as well as pre-established measures such as UN HDI which focus on the national level. Thus it was important to see what data would be available to represent the capabilities of urban residents at a scale of greatest possible detail. Secondly, since urbanization in the 21st century is largely a developing world phenomenon, the study areas would be cities in developing countries where data availability is very poor. Mumbai, one of the largest cities in India was one of the cities of interest. Therefore, datasets used were based on the kind of data available for Mumbai. This is further elaborated in section 2.5.3

In order to ascertain the kind of data that might be available for the study area, a detailed study was undertaken which investigated the public bodies, administrative departments, academic institutions, non-government organizations, and private companies which were involved in the data collection and planning activities of the area. A tentative list of the types of data that might be available was therefore prepared as a result of this study.

Simultaneously, a study of pre-established development indicators of international public consensus was done, to understand the capabilities that are measured for the purposes of

other studies. It was hoped that this study would identify the indicators of development that were most repetitive, i.e., the ones that had been used widely even after years of debate and analysis and hence allow the process to formulation of measures to be comprehensive and helpful in creating a list which is exhaustive and non-reductive.

2.6 Study of International Development Indicators

As previously discussed, the study of pre-existing measures which have been accepted by consensus at the local, national or international level is an conventional way of framing measures for assessing human security, development, and capabilities. This section discusses some development indicators which are accepted at the international level.

2.6.1 United Nations (UN) Human Security Indicators

Prior to the United Nations 1994 Human Development Report "New Dimensions of Human Security", human security was perceived to be an indicator depicting the military strength and security of the sovereignty of a nation. "The 1994 Report introduces a new concept of human security, which equates security with people rather than territories, with development rather than arms." The report focused human development with 20% of national funds and 20% of foreign aid being prescribed to be used for human development. It brought about a shift due to which human security is now discussed as a measure for 'freedom to live a life of dignity' and hence, focuses on the security of individuals.

The human security indicators are defined by a combination of seven security parameters and are an important and effective measure for assessing the quality of life of the citizens. These 7 security parameters are,

1. **Economic security** — Economic security is attained by an assured basic income for individuals, usually from productive and remunerative work or, as a last resort, from public funding. While this is a more serious issue in developing countries, it has universal relevance as unemployment is an important factor underlying political tensions and ethnic violence.
2. **Food security** — Food security requires that food can be accessed by all people at all times. The distribution and purchasing power of food are the biggest concerns of food security.
3. **Health security** — Health Security concerns are disparate for developed and developing countries ranging from obesity to malnutrition and infectious diseases. This security measure aims to assure a minimum protection from diseases and unhealthy lifestyles for everyone.

4. **Environmental security** — Environmental security aims to protect people from the natural and man-made threats of the natural environment. This ranges from concerns such as access to clean water, to effects of global warming.
5. **Personal security** — Personal security is a protection of individuals from violence and crime whether it is caused by other individuals, the state, or external agencies.
6. **Community security** — Community security protects the integrity of ethnic and religious groups and protects them from prosecution and bias.
7. **Political security** — Political security aims to protect the basic human rights of people, by protecting against repression, corruption, and torture.

However, it does not indicate the levels of social inequality in issues such as illiteracy, gender inequality, maternal health, and child mortality. Additionally, it does not include the issues of environmental sustainability in the context of pollution, urban squatters, and depleting natural resources.

Several other such measures have been discussed here in an attempt to compensate for the shortcomings of the Human security Indicators, and their strengths, weaknesses and applicability have been identified.

2.6.2 UN Human Development Index

The United Nations Human Development Index was among the first attempts to quantify the levels of human development of countries, at a time when the GDP (Gross Domestic Product) was the only form of measuring a country's "standing" in world society. Its proponents argued that the GDP of a country does not reflect the quality of life of the people of the country. A country with very high GDP may have a very wide gap between the rich and poor populations and hence, should not be considered to be exemplary as compared to other countries of lower GDP but greater equality. The HDI also stressed that simply having the means to a high quality of life does not ensure that the ends are met. There exist many factors which inhibit the effective conversion of means to ends for each person. For example, there are several countries which are very rich in oil resources due to which their GDP is very high but have low levels of education and inequality against women which are not accounted for. It is therefore important to measure the level of education and health of the people of a nation in addition to their per capita income.

The Human Development Index used three indicators namely, Income, Health and Education to form a composite for measuring Human Development.

1. **Income** – Measured by gross national income per capita
2. **Health** – Measured by life expectancy at birth

3. **Education** – Measured by mean years of schooling and expected years of schooling.

Although this was a good first step towards including the social aspects of development, it has several shortcomings. Firstly, if the GDP is high, then the average health services and education services are also usually high and so, not many changes are seen from the GDP measure. Secondly, the inequality adjusted HDI was introduced in 2010. Before that, the inequality within nations was not accounted for. And thirdly, the HDI does not account for good governance and freedom of the individuals and is too simplistic in its objective to reflect a nation's well-being through just three factors.

2.6.3 UN Millennium Development Goals

Unlike the indicators discussed so far, the Millennium Development Goals (MDGs) are specifically tailored for developing countries, aimed towards ending poverty by the year 2015. It is composed of eight goals each with several sub goals which focus at various issues related to poverty in developing countries and suggest mechanisms in which they can be eradicated. These goals are:

1. Eradicate Poverty and Hunger
2. Literacy
3. Woman Empowerment & Gender Equity
4. Low Child Mortality
5. Maternal Health
6. Combat Disease
7. Environmental Sustainability
8. Governance

The MDGs lay special stress on educating and empowering women. This is because it is believed that if women are educated and self-reliant, it will result in far reaching social advantages. Firstly, the number of children she has will go down, which will benefit the family as it will have fewer mouths to feed and the entire country in the long run. Also, the health of the entire family will improve as she will ensure cleanliness and take protection against mosquitoes and other vectors borne diseases. Additionally, if she is an earning member of the family, then female foeticide will go down and the next generation of girls will also be educated. It is also believed that educated women save money and invest it for the betterment of the whole family.

2.6.4 UN Urban Development Indicators

The UN Sustainable Development Indicators are devised to work as a comprehensive checklist of planning priorities that must be addressed in order to plan for sustainable urban development. The indicators are organized under four broad categories of planning themes namely, **Social**, **Environmental**, **Economic**, and **Institutional**. Although the list of indicators is exhaustive, it is very difficult to find data pertaining to the respective indicators for the proper application of this measure. The data on most of the sub themes are available for the national scale, but will be unavailable for cities. These indicators are a valuable source of reference for ensuring that all the aspects of sustainable development are covered, but their modification according to available data is necessary.

2.6.5 World Bank Good Governance Indicators

Governance is an extremely important aspect of human security. Liberty and Rule of Law form the central aspects of human security. According to the World Bank, political stability is gauged by the level of good governance, which in turn is decided by the level of **participation** and **voice** of each citizen, **accountability** and **transparency** of the administrative system, degree of **control over corruption** and **discrimination** between different groups, **regulatory quality** and **rule of law**. These multiple indicators of urban governance are therefore a valuable addition in the measurement of human security.

2.6.6 Universal Declaration of Human Rights

The Universal Declaration of Human Rights was adopted by the UN on 10th December 1948 as a response from the lessons learnt from World War II, and was the first global expression of rights to which all human beings are inherently entitled. Although not a legal document in itself, it had been the foundation for several UN covenants of civil, political, economic, social and cultural rights, and continues to be a moral reference for all nations.

During World War II, the Allies adopted the Four Freedoms – freedom of speech; freedom of religion; freedom from fear; and freedom from want – as their basic war aims as spoken by then US President Franklin D. Roosevelt in the State of the Union Address on 6th January, 1941. The United Nations Charter "reaffirmed faith in fundamental human rights, and dignity and worth of the human person" and committed all member states to promote "universal respect for, and observance of, human rights and fundamental freedoms for all without distinction as to race, sex, language, or religion".

When the atrocities committed by Nazi Germany became apparent after the war, the consensus within the world community was that the United Nations Charter did not sufficiently define the rights to which it referred. A universal declaration that specified the rights of individuals was necessary to give effect to the Charter's provisions on human rights. Thus the Universal Declaration of Human Rights was commissioned. Although not a legally binding document, the articles of this declaration prompted global discussion about human rights and were instrumental in the emergence of all the measures outlined in this chapter.

2.7 Study of Normative assumptions – Theories of Human Needs

A study of some normative theories of human needs was done to understand the basic needs of human beings which are deeply connected to the basic capabilities required for an acceptable standard of life. While some theories suggest that the needs change with time and cultural backgrounds, others suggest that the basic needs are universally applicable and unchanging however, the way in which they are satisfied differs from place to place.

2.7.1 The Max-Neef Model of Human-Scale Development (1989)

Max-Neef's work criticizes the appropriateness of conventional models of development which often result in increasing poverty, massive debt and ecological disasters. He endorses development oriented towards stimulating and addressing local needs.

Max-Neef and his colleagues have developed a taxonomy of human needs and a process by which communities can identify their "wealths" and "poverties" according to the extent to which the human needs are satisfied. Human Scale Development is defined as "focused and based on the satisfaction of fundamental human needs, on the generation of growing levels of self- reliance, and on the construction of organic articulations of people with nature and technology, of global processes with local activity, of the personal with the social, of planning with autonomy, and of civil society with the state." (Max-Neef *et al*., 1987:12)

Max-Neef postulates that human needs are few, finite, classifiable and constant through all human cultures and historical time periods. There is no hierarchy such as that postulated by Maslow (Table 2), instead, there is simultaneity, complementarity and trade-offs between the various needs and their satisfaction i.e., they are interrelated and interactive. The satisfiers may be classified as violators, pseudo-satisfiers, inhibitors, singular satisfiers, or synergic satisfiers, based on their effects on individuals and society. The distinctive feature between cultures and time periods that makes the needs specific to such situations is the way in which the needs are satisfied. This model is a useful approach for deep reflection and understanding of the strengths

and weaknesses of individuals and communities, leading to critical awareness and possibly, action at the local economic level.

The fundamental human needs and their existential categories form a 36 cell matrix which is filled in by examples of satisfiers as shown in Table 2.1.

Table 2. 1 Max - Neef Model

Fundamental Human Needs	Being (Qualities)	Having (Things)	Doing (Actions)	Interacting (Settings)
Subsistence	Physical and mental health	Food, shelter, work	Feed, clothe, rest, work	Living space, social setting
Protection	Care, adaptability, autonomy	Social security, health systems	Co-operate, plan, take care of, help	Social setting, dwelling
Affection	Respect, humour, sensuality	Friendships, family, nature	Share, care for, make love	Privacy, intimate spaces
Understanding	Critical capacity, curiosity, intuition	Literature, teachers, policies	Analyse, study, meditate	Schools, families, universities
Participation	Receptiveness, dedication	Responsibilities, rights, duties	Co-operate, dissent, express	Associations, parties, churches
Leisure	Imagination, tranquillity	Games, parties, peace of mind	Day-dream, remember, relax	Landscapes, intimate spaces
Creation	Imagination, boldness, curiosity	Abilities, skills, work, techniques	Invent, build, design, work	Spaces for expression
Identity	Belongingness, self esteem	Language, religions, values	Self-reflection, commit	Places one belongs to
Freedom	Autonomy, passion, self -esteem	Equal rights	Dissent, choose, run-risks, develop awareness	Anyplace of one's choosing

Max-Neef's model uses "means" as well as "ends" to measure the extent to which human needs are met. The "Things" and the "Settings" represent the "means" required to be able to meet one's needs. The "Qualities" and the "Actions" represent the "ends" that the individuals are capable of achieving which is a good indicator of the strengths of individuals and communities.

2.7.2 Nussbaum's formulation

Martha Nussbaum's theory is a branch of the capabilities approach propounded by her and Amartya Sen which attempts to define well-being in an objective way, by identifying a set of core human capabilities that are critical to full human functioning and assessing well-being (and the success of development policies) by the degree to which the individual is in circumstances which lead to the realization of these capabilities. She, like Max-Neef, holds the belief that the capabilities that are essential for leading a good human life are substantially independent of cultural variations. A list of the essential capabilities has been carefully

constructed to serve as a guide as well as a critical standard for development policies. The capabilities are summarised below:

1. Being able to live to the end of a human life of normal length.
2. Being able to have good health, adequate nutrition, adequate shelter, opportunities for sexual satisfaction and choice in reproduction, and mobility.
3. Being able to avoid unnecessary and non-beneficial pain and to have pleasurable experiences.
4. Being able to use the senses, imagine, think, and reason; and to have the educational opportunities necessary to realize these capacities.
5. Being able to have attachments to things and persons outside ourselves.
6. Being able to form a conception of the good and to engage in critical reflection about the planning of one's own life.
7. Being able to live for and to others, to recognize and show concern for other human beings.
8. Being able to live with concern for and in relation to animals and the world of nature.
9. Being able to laugh, to play, to enjoy recreational activities.
10. Being able to live one's own life and no one else's; enjoying freedom of association and freedom from unwarranted search and seizure.

Nussbaum says, “My claim is that a life that lacks any one of these capabilities, no matter what else it has, will fall short of being a good human life” (p. 85). “The basic claim I wish to make . . . is that the central goal of public planning should be the capabilities of citizens to perform various important functions” (Nussbaum and Glover, p. 87).

2.7.3 Other theories of Human Needs.

Max-Neef’s model and Nussbaum’s theory discussed above strongly rely on the capabilities of individuals to assess the degree of fulfilment of needs. A few other popular theories of human needs are discussed in Table 2.2.

Table 2. 2 Other Normative Theories of Human Needs

Theory and Proponent	Needs	Comments
Instinctive and universal needs - Maslow (1943)	Physiological needs, Safety needs, Affective needs, Esteem, Self-actualization	Maslow described the first four needs as deficit needs or D-needs which meant that if one did not have enough of any of those needs, s(he) would feel the urge to get it. He also identified a set of B-values or "Being- cognition" which when fulfilled, gave rise to "peak experiences". These were profound moments of extraordinary feelings of love, oneness, self-sufficiency, etc., which could only be felt by self-actualizing people. Maslow's **needs were hierarchical** which meant that an individual would only endeavour to fulfil higher needs when the lower needs had been met although one could feel various needs at once. An individual could only reach full potential when all the needs are fulfilled. It is very difficult to quantify this theory to measure the degree to which human needs are met since qualities such as "self-actualization", esteem, affection, etc., are **extremely subjective and based on the perception** of each individual. This theory therefore **lacks empirical analysis.**
Primary Goods - Rawls (1971) (Means)	Rights, Liberties, Opportunities, Income and wealth, Freedom of movement & choice of occupation, Social bases of self-respect, Powers & prerogatives of offices and positions of responsibility	John Rawls introduced a list of Natural and Social primary goods which were presumed to be desired by every individual. The **access to and possession of** these primary goods was therefore used as the **basis of justice** for individuals and communities. Although it is based on the access to various "means", the primary goods reflect the situation within which one is able to take part in communal life and exercise their democratic rights. This essentially **reflects one's capabilities.**
Intermediate needs - Doyal & Gough (1991)	Nutritional food/water, Protective housing, Work, Physical environment, Health care, Security in childhood, Significant primary relationships, Physical security, Economic security, Safe birth control/ childbearing, Basic education	Doyal & Gough discuss needs as "health needs" which are the **fundamental requirements** to stay alive, and "autonomous needs" which are related to the **cognitive needs** to achieve conscious goals. As with Maslow's theory, the "health needs" need to be satisfied in order for the "autonomous needs" to become important. They formulated a list of **eleven "Intermediate needs"** which are universal satisfiers for the "health needs" as well as "autonomous needs".
Instrumental Freedoms Sen (1999)	Political freedom, Economic facilities, Social opportunities, Transparency guarantees, Protective security	Sen proposes a list of freedoms which are achieved through the fulfilment of needs, which gives an individual the capability to lead a substantial life. The degree of substantiality of each freedom governs the degree of one's well-being. These also have an instrumental role in development, as **governance should be aimed at enabling these freedoms**.

2.8 Assimilating International Development Indicators and Normative Theories of Human Needs for formulating Development Indicators

The normative theories studied help to capture a comprehensive view about the various aspects of satisfactory living. The common denominator in each of these theories is the emphasis on basic requirements for subsistence, such as food, shelter and safety. Some of the theories take on a hierarchical order of needs where each of the needs higher in hierarchy becomes important once the lower needs have been satisfied, with the higher needs being related to affection, belongingness, liberty, equality and identity. Other theories specify that all the needs are desired at the same time and by all individuals whether they are needs of subsistence or to satisfy cognitive desires and the failure to achieve any one of them will cause dissatisfaction.

The normative theories of human needs offer insights into the needs of individuals to lead a satisfactory life. They do not rely on aggregation to gauge the overall development levels as is done by the pre-established development indicators discussed in section 2.6. The normative theories of human needs are designed to account for the inequalities felt by each individual residing in society and therefore are the ideal parameters for measuring human security and consequently framing development initiatives taking into account each individual's needs.

Although idealistic, it is very difficult to translate these theories into quantifiable measures due to various reasons. Firstly, the satisfaction for most of the needs is based on the perception of individuals, for which gathering data is a challenge. The same physical situations may translate into very different levels of capability for different individuals. Additionally, a multitude of different satisfiers may be used by different people to achieve similar capabilities and consequently, these similar capabilities may be expressed in having and being a multitude of different ways. Measuring the levels of satisfaction of perceived needs, and further associating them with quantifiable observable indicators for use in development planning is therefore unrealistic. Additionally, although understanding human needs at the individual level is good in principle, cities do not have data available at the individual level and neither can development policies be formulated to address individual desires. A certain level of aggregation is acceptable and necessary for analysing levels of development and framing pointed actions for their improvement.

The normative theories and the international development indicators must therefore be used to create a balance between the micro scale (individual level) of the former and the macro scale of the latter (national level) in the process of formulating Development Indicators to

measure human security in cities. Additionally, the international development indicators may be adapted for quantitative measurement of human development indicators. However; the representative data used to make such measurements must be carefully selected from implicit and explicit assumptions of locally valued capabilities, understood using informed knowledge about the city, analysed using the understanding of the normative theories of human needs (Fig.2.1).

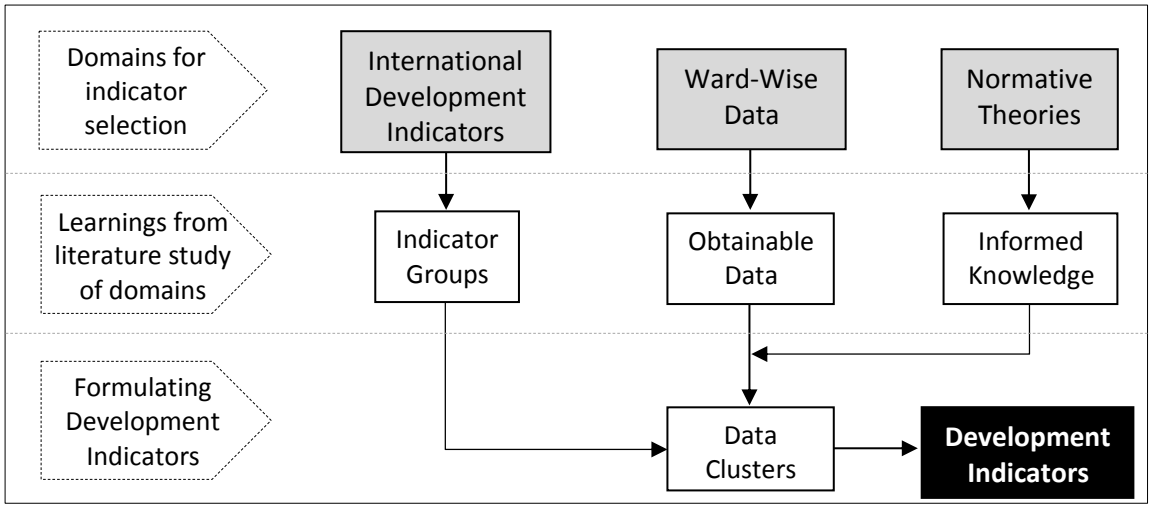

Fig. 2. 1 Formulating Development Indicators

2.9 Development Indicators (DI) for Assessing Human Security

The meaning of the concept of Human Security interpreted in this research equates insecurity to capability deprivation as discussed by Amartya Sen in "Development as Freedom" and hence aims to measure, using the Development indicators (DI), the degree of relative freedoms of the inhabitants to make choices regarding their economic and social situation. In "Development as Freedom", Amartya Sen states that capability deprivation can debilitate an individual and disallow the realization of the goals one sets for oneself. It is highly relative; being relatively poor in a rich country can lead to social exclusion, siblings may have different levels of access to the parent's income and various social factors may be a hindrance in one's ability to convert income into capability. So, capability deprivation translates into insecurity and the instruments significant to capability deprivation such as income, education, health, social exclusion, etc., are essentially tools for measuring insecurity (DI). These cause relative deprivation which is why DI must be measured for each urban area separately and the variations within the urban area are significant in expressing insecurity.

2.9.1 Scale of measurement

This research lays emphasis on the need to measure human security at the micro level. A measurement of the level of security of each individual over each location measured over time is the best way to understand patterns and relationships of human security with other factors of the urban system. However, since measuring the capabilities of each individual and addressing each issue for development planning is not practical, a suitable scale of aggregated measurement must be specified. This scale of measurement must be small enough to capture the inequalities existing within citizens and yet be a scale at which data is readily available.

Neighbourhood level data is ideally the best representation of identity, belonging, social status and economic position (Kearns and Parkinson, 2001). It is quite homogenous in the level of satisfaction of the basic needs of its residents and in providing them with similar opportunities. The inequalities between different neighbourhoods would therefore be a good representation of the disparities present in the urban area. However, neighbourhood level data is not readily available especially in cities of developing countries, which form a major part of this research. The smallest geographical unit at which data is available in these cities is the ward level. Wards are administrative units within cities that elect their councillor who is responsible for local governance and for representing the ward's population and communicating their issues and concerns to the city government. Although wards are more heterogeneous than neighbourhood units, they have defining characteristics based on the following:

1. Ward boundaries usually follow geographic or historic contours which give wards specific identity and character.
2. They are the basic administrative units of the city
3. They represent small urban ecosystems with shared attributes such as pollution, congestion, etc.

Ward level data has been used in this research in an attempt to identify and analyse the disparity in human security among city wards in the cities studied.

2.9.2 Quantities of measurement

The International Development Indicators were used to derive the categories of the Development Indicators. The complete and exact application of all the indicators discussed in section 2.6 was not possible due to unavailability of several datasets at the ward-wise level. Additionally, there exists a considerable amount of overlap between the indicator sets, which would be redundant if applied a multiple number of times. Therefore, simplification, conjugation and modifications according to available data were required. To reduce this

repetition, each of the development indicators were analysed based on their definition and representative data and were seen to fall into six categories; Economic equity, Health, Education, Social Equity, Environment and Good Governance, as shown in Table 2.3.

Table 2. 3 International Development Indicators

UN Human Security	UN Human Development Index	UN Millennium Development Goals	UN Sustainable Development Indicators	World Bank Good Governance Indicators
Economic Security	Income	Eradicate Poverty and Hunger	Social	Voice and accountability
Food Security	Health	Literacy	Economic	Stability and Non-violence
Health Security	Literacy	Woman Empowerment & Gender Equity	Environmental	Government Effectiveness
Environmental Security		Low Child Mortality	Institutional	Regulatory Quality
Personal Security		Maternal Health		Rule of Law
Community Security		Combat Disease		Control Corruption
Political Security		Environmental Sustainability		
		Governance		

Economic equity
Health
Education
Social Equity
Environment
Good Governance

The above mentioned six categories therefore represent the **six indicators of development found in all of the International Development Indicators**. Since the issue of overlap had been resolved, an investigation of suitable data representation was done to see if these indicators could be applied for quantitative measurements.

A study of obtainable ward-wise data was undertaken, focussed on the Indian cities of this research, where data is scarce. Census data was the most common and comprehensive source of ward-wise data available in these cities, with additional data available from NGOs, academic institutions, planning bodies and private practitioners and a list of “obtainable data” was created from this study. A matrix was created with the International Development Indicators on the horizontal axis and the obtainable data on the vertical axis (see Table 2.4). After this, the two lists were compared and the indicators which had similar data representation in the obtainable dataset were marked. Finally, the cumulative scores for all the indicators and the data were found. This was done by adding the vertical columns and horizontal rows of indicators and data, respectively. This was done to serve two purposes; firstly, to find which of the indicators had maximum representation in the dataset, and secondly, to

find the available datasets that most strongly reflected specific aspects of the capabilities or development levels of the people.

Table 2. 4 Investigating data representation of Development Indicators

		International Development Indicators																																	
Development Indicators (DI)		UN Human Security Indicators							UNDP Millennium Development Goals Indicators									UN HDI Indicators			UN Sustainable Development Indicators				World Bank Good Governance Indicators										
●	Income and Economic Equity	Economic	Food	Health	Environmental	Personal	Community	Political	Poverty	Hunger	Education	Gender equity	Woman empowerment	Low child mortality	Maternal health	Combat disease	Environmental sustainability	Good governance	Health	Education	Income	Social	Economic	Environmental	Institutional	Voice and accountability	Stability and non- violence	Government effectiveness	Regulatory Quality	Rule of Law	Control Corruption					
●	Health																																		
●	Education																																		
●	Social Equity																																		
●	Environment																																		
●	Good Governance																																		
Obtainable Data (Ob Data)		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d				
1	Main / Formal Employment - Total	●							●												●		●												4
2	Marginal / informal Employment -Total	●							●												●		●												4
3	Unemployment - Male, Female, Total	●							●												●		●												4
4	Net Income of wards, or average income of people in each ward	●							●												●		●												4
5	Total number of households Below Poverty Line	●							●												●		●												4
6	Number of slums and number of slum houses	●							●												●		●												4
7	Number of chawls and chawl houses	●							●												●		●												4
8	Average land price of Highly developed, developed and raw land, in each ward	●																			●		●												3
9	Average rent of each ward	●																			●		●												3
10	Ward-wise total number of Deaths			●												●			●																3
11	Ward wise average life expectancy			●												●			●																3
12	Children under age 6													●		●																			2
13	Population by age groups													●																					1
14	Total number of people affected by disease			●										●		●			●																4
15	Child mortality		●	●						●				●		●			●																6
16	Number of children under 5 years of age who are underweight		●	●						●				●	●				●																6
17	Total number of undernourished population		●	●											●				●																4
18	Number of hospital beds available in public and private facilities													●	●	●			●																4
19	Literates - Male, Female, Total										●									●															3
20	Number of school seats available in public and private facilities										●									●															2
21	Enrolment/Dropout Rate										●									●															2
22	Teacher-student Ratio										●									●															2
23	Number of females per 1000 males											●	●									●													3
24	Main Employment - male / female											●	●									●													3
25	Marginal Employment- male / female											●	●									●													3
26	Total area of each land use (total residential area, commercial area, industrial, roads,...etc.) in each ward				●												●							●											3
27	Number of major *Nalas* (open drains)				●												●							●											3
28	Number and dimensions of brown fields per ward				●												●							●											3
29	Rate of spatial growth of ward area				●												●							●											3
30	Rate of deforestation in each ward				●												●							●											3
31	Max Air pollution level of each ward				●												●							●											3
32	Max water pollution level of each ward				●												●							●											3
33	Flooding Points				●												●							●											3
34	Government spending per capita							●										●																	2
35	Local government revenue per capita							●										●										●								3
36	Percentage of people involved in community decision making							●										●								●										3
37	Citizen report card scores																	●								●		●	●		●				5
38	Crime rate							●										●									●	●	●						5
		9	3	6	8	0	0	4	7	2	4	3	3	6	3	6	8	5	7	4	9	3	9	8	0	2	2	2	2	0	1				

Each of the six indicators of Economic equity, Health, Education, Social Equity, Environment and Good Governance were seen to have associated representative data in the list

of obtainable data. These are therefore the indicators for development or Development Indicators (DI) and the representative data can be used to quantify each of these indicators for each city (Table 2.5). The measurement of quality of urban development can therefore be carried out by the composite assessment of the aforementioned indicators, which aim to understand and quantify urban development and its effects on the individuals from various backgrounds inhabiting the city.

Table 2. 5 Development Indicators (DI)

Development Indicators (DI)	**Major Datasets**
① Income and economic Equity	Employment data, Average household income, Households below Poverty Line, Slum population, Average land price.
② Health	Average life expectancy, Number of people affected by disease, Child mortality, Number of hospital beds available.
③ Education	Literates, Ratio of school seats to population, Number of females per 1000 males.
④Social equity	Number of households, with access to clean water, sewerage facility, electricity, telephone, Ratio of ward wise solid waste generated to amount treated.
⑤ Environment quality	Number and dimensions of brown fields per ward, Rate of spatial growth of ward area, Maximum Air pollution level, and Maximum water pollution level.
⑥ Good Governance	Government spending per capita, local government revenue per capita, Crime Rate.

2.10 Conclusion

This chapter has explored the theoretical understanding and the evolutionary context of the concept of Human Security in relation to development. Various approaches of evaluating security, namely the commodity based, utility based and capability based approaches have been discussed out of which the capability based approach has been selected for this research. After this, a methodology of selecting suitable parameters for the quantitative and comprehensive measurement of human capabilities has been presented. The study of various pre-existing development indicators, normative theories of basic human needs and a look at the available data have resulted in the construction of five Development Indicators (DI), which can be used to quantitatively assess the quality of human security in urban areas. Thus the first objective of this research as listed in the previous chapter, has been achieved.

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Chapter 3:

METHODOLOGY FOR FORMULATING URBAN DENSITY MEASURES

"..Adding further to the confusion came a statistical monstrosity much used by reformers to aid their housing-profit crusades—a raw figure of number of persons per acre. These menacing figures never tell how many dwellings or how many rooms there are to the acre, and if the figure is given for a badly troubled area—as it almost invariably is—the implication is deafening that there is something dreadful, on the face of it, in such heavy concentrations of people."

- Jane Jacobs, 1961

3.1 Definition of Urban Density

Urban Density may be defined in the most elementary form as the *number of units of a certain urban element existing in unit measure of a second element over which the first is distributed.* The selection of the urban elements to be included in the measure depends on the purpose for using the density measure (Equation 3.1)

$$D = \frac{A}{B}$$

D – Urban Density
A – Element whose density is to be measured
B – Element on which density is to be measured (on which A is distributed)

Equation 3. 1 Calculating Urban Density

The purpose defines the type as well as scale of the density measure. The purpose of policy makers for example is usually concerned with the physical occupation of urban land by people or built structures. The urban density measures used, compute the number of people or structures existing in unit urban area. The specific purpose defines the scale hence producing different measures such as metropolitan density (number of people in total area), gross neighbourhood population density (number of people in total neighbourhood area), net neighbourhood population density (number of people in habitable area), occupancy density (number of people in individual dwellings divided by total floor area), etc.

The purpose of the density measures used in this research is to assess how elements of crowding may affect the lives of urban residents. The density measures used must therefore be able to assess a wide range of systems with which urban residents interact and must be measured at a very small scale in order to report the results of each individual. That being said, data availability is a limiting factor as standard census data (often the only data available especially in developing countries) is only representative of a few urban systems and the smallest scale in which it is available is at the ward level.

3.2 What creates Urban Density?

The distribution of different density elements in the urban area depends upon the economic, social, physical, political and environmental systems that make up a city and ways in which the urban inhabitants interact with these systems. Residential density for example, reflects the residential choice of different groups of people affected by rent value, job availability, infrastructure availability, economic classes of existing residents, existing ethnic communities, daily commute time and cost, and many other factors. It is therefore a reflection of a variety of factors which need to be understood individually in order to understand the

metrics effecting residential choice. Although residential density is the most widely used urban density measure applied to the assessment and modelling of population distribution (usually only on economic factors) in urban space, it is of paramount importance to understand the density or per unit availability of the actual factors that affect residential choice in order to understand the implications of residential density in lives of urban inhabitants and the objectives thereof of urban planning. Thus new measures of density must be formulated which successfully capture a wide range of urban systems affecting choices of the urban population, for example, the factors showed in Fig. 3.1.

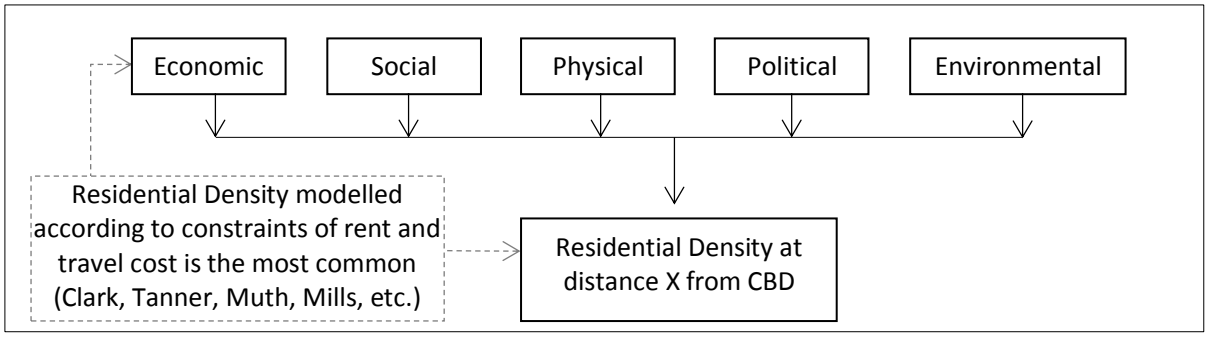

Fig. 3. 1 Factors affecting residential density

3.3 Urban Density Gradient Models

Cities provide variety and differentiated opportunities for a common life which is why people choose to live in cities in developed and developing countries. Modelling the distribution of a wide range of density differentials effectively as a tool for city planning can facilitate many social functions, emphasize an organic relationship between people and their living spaces, celebrate the wide array of opportunities created by diverse social interaction, provide occupational opportunities, encourage artistic expression, cater to heterogeneous cultures, and create areas characterized by dynamic markets and global experiences.

The mathematical estimation and modelling of urban density has been of great interest to urban economists, geographers, and urban planners for over half a century. Most of these are economic models of gross residential density. A review of these models is undertaken in order to understand the economic factors that control residential choice.

The various urban density models can be typified as mono-centric vs. polycentric and mathematically segregated as the negative exponential model, inverse power function, cumulative growth function and linear functions.

3.4 Negative Exponential Density Functions

The negative exponential function is used to model gross urban residential density based on distance from the central business district (CBD) of the city claiming that density falls exponentially with changing distance. The theoretical basis is that assuming all the jobs are located at the CBD, housing choice will depend on a trade-off between housing prices and commuting prices to the CBD. People living far away from the CBD will have to pay low housing cost (as demand is less) but greater transport cost and people living close to the CBD will pay high housing cost but low transport cost. So considering that the wages of all workers are similar, at equilibrium condition, density will fall off exponentially with distance from the CBD.

The negative exponential function was first used by Clark (1951) to model urban density in mono-centric cities. This function has been tested empirically and adapted using several functional variants over the past six decades. Examples include the various transformations of the negative exponential (Casetti, 1969), the binomial density function (Mills, 1972), the normal (Newling, 1969), gamma (Aynvarg, 1969; Amson, 1972a), mesotropic (Amson, 1972b), polynomial (Frankena, 1978), trend surface (Hill, 1973), cubic spline (Anderson, 1983), a spatial autoregressive formulation (Griffith, 1981; Anselin, 1984c), and the variable (Box-Cox) functional form of Kau and Lee (1976a, 1976b). The urban density gradient models associated with the negative exponential function are discussed in this section.

3.4.1 Colin Clark, 1951

For each city Clark drew a series of concentric rings, spaced at intervals of one mile, centred on the city centre. Using census tract data, and excluding the central business districts, he calculated the average density at each concentric circle, and regressed the natural log of density on distance from the city centre. He concluded that density falls off exponentially in all cities at all times (Equation 3.2) and that the density functions become flatter through time. The latter observation is attributed to declining real cost of transportation through time.

$D_x = D_0 e^{bx}$	D_x – Average density at distance x from CBD D_0 – Average density at CBD x – Distance from CBD b – Rate at which the effect of distance attenuates

Equation 3. 2 Clark's Negative exponential function

Clark applied his theory to empirical data and fitted the log transform of equation 1 to over 20 American cities using linear regression. Furthermore, Clarke also discussed how the rate factor *b* changes with time. Many researchers after Clark have also suggested modifications to the original negative exponential function given by Clark, to acquire a more robust fit to empirical data as well as to make it more theoretically explicit.

Clark's study is deficient in a few ways. In his statistical method he does not present any multiple correlation coefficients, significance tests of his regression coefficients, or tests for the linearity of his logarithmic regression equations. Additionally, the theoretical premise fails in case of dispersed employment centres, influence of government on urban land use and inequality in wages. However, his theory charted the path for all further work on urban density functions and there is a large body of empirical research that supports Clark's theory which is why it is still held as one of the most widely accepted density function. Furthermore, his statement about the gradient *b* reducing over time encouraged many urban economists to investigate phenomenon of city growth and diversification.

3.4.2 J. Tanner, 1961

Sherratt (1960) and Tanner (1961) carried out empirical research on Clark's theory and observed that a negative square exponential distribution (Equation 3.3), that is, a normal distribution; will often fit the empirical data better.

$D_x = D_0 e^{bx^2}$	D_x – Average density at distance x from CBD D_0 – Average density at CBD x – Distance from CBD b – Rate at which the effect of distance attenuates

Equation 3. 3 Tanner's Normal distribution function

3.4.3 Y. Aynvarg, 1969

Aynvarg suggests that a gamma distribution (Equation 3.4) describes more accurately the population pattern especially over an extended 'zone of influence' surrounding a central city.

$D_x = D_0 x^a e^{-bx}$	D_x – Average density at distance x from CBD D_0 – Average density at CBD x – Distance from CBD b – Rate at which the effect of distance attenuates a – constant depending on population of city

Equation 3. 4 Aynvarg's Gamma distribution function

His study involved the use of data from small and middle sized cities with radial distances of up to 30 kilometres from the centre. Aynvarg presented a graph relating the three constants used in his density function; D_o, *a* and *b* derived from his observations of several Ukrainian cities of population less than 135000 people. When *b* is small as compared to *a,* Aynvarg's function acts like the inverse power model and when *a* is small as compared to *b*, the distribution approximates Clark's negative exponential model. The gamma model is therefore a combination of the negative – exponential density model and the inverse – power model and so has a pragmatic advantage in being flexible in adapting to either distribution and obtaining better fit for a larger range of situations.

3.4.4 B. Newling, 1969

Newling (1969) recommends a generalization of the negative exponential model and the normal model to suggest the quadratic negative exponential distribution (Equation 3.5) for modelling urban densities.

$D_x = D_0 e^{(bx-cx^2)}$	D_x – Average density at distance x from CBD D_0 – Average density at CBD x – Distance from CBD b – Rate at which the effect of distance attenuates c – Constant measure of rate of change of *b*

Equation 3. 5 Newling's quadratic negative exponential function

A negative value of *b* and a zero value of *c* in Newling's model, transforms it into Clark's model. Alternatively, a zero value of *b* and a positive value of *c* gives Tanner's normal model. Interestingly, when b is large (which it is typically close to the CBD), instead of the maximum density being at the centre of the city, it is now at a specific radial distance from the CBD hence producing a population density crater surrounding the CBD. The existence of a crater of residential population density can be explicitly justified in most North American cities as they typically have non-residential CBDs. Differentiation shows the point of maximum density to be at *b/2c* units from the centre. Furthermore, two points of inflection are found on either side of the "crest" at distances of $[b \pm (2c)^{1/2}]/2c$ where the density is 60.7% of the density at the crest. The coefficient *c* provides a better fit of the model especially at the edge of the city where *b* typically reduces significantly.

Newling suggests that a city evolves from a negative exponential density distribution to a normal distribution to a quadratic negative exponential distribution throughout its life cycle as

it grows. Newling also showed a strong correlation between density and rate of growth using his model. He determined a critical density (32,000 persons per square mile), above which the rate of growth is negative and below which the rate of growth is positive. He suggested that the calculation of critical densities for other cities might be important for the field of planning and that there might be an optimum urban density.

3.4.5 Richard Muth, 1961, 1969

Muth selected for study, the central cities of 46 large urbanized areas, eliminating those with two or more central cities and those whose CBD's could not be identified. Within each of the 46 central cities he selected 25 census tracts at random and determined their gross population densities for 1950 and using the negative exponential function and measuring the distance between the city centre and the centres of the census tracts. For each city, Muth regressed the natural log of census tract population density on distance from the CBD Centre. The correlation coefficient between log of density and distance is significant for 40 out of the 46 cities. Muth's estimated density gradients (*b*) vary from 0.07 to 1.20, but most fall between 0.2 and 0.5. He believed that differences in density gradients among metropolitan areas were to be explained by three sets of factors:

1. The nature and cost of commuting by transportation available to CBD workers
2. The spatial distribution of employment and shopping centres
3. Preferences for housing in various parts of the city

He estimated and tested the importance of these factors by regressing the density gradients on several variables believed to be measures of the three sets of factors. Among the variables found to be significant in explaining the density gradients were car registrations per capita, the proportion of the metropolitan area's manufacturing employments located in the central city, and the proportion of the central city's population of African origin. Using these and similar variables, Muth was able to explain about 70% of the variance of the log of the density gradients.

3.4.6 Edwin S. Mills, 1969

He formulated a simultaneous equation model of land values and land uses in a metropolitan area. Within the framework of his model, he showed that the negative exponential function can be used to approximate the decline of both land values and the density of land uses as one moves out from the city. The measure of "density of land use" is floor space per acre of land in several use categories; residential, manufacturing, commercial

and public. Regression of log density on distance from the city centre provides a good fit but with uniformly lower R^2 values than the regression of log of density on log of distance.

Similar to Muth, Mills also took great interest in the density gradient *b* and stated it to be a measure of decentralization or suburbanization in an urban area. It can be used to compare various phases of one city or for comparing two or more cities at the same point in time. If *b* falls from one census year to the next, it would imply that the area has suburbanized in those years. Also, if an urban area has higher *b* than another then the former can be said to be more urbanized.

Mills also discussed the various factors that affected *b* (Equation 3.6). Firstly, he stated that the higher is the **average income**, the smaller will be *b*. This is because the higher is the income, higher is the demand for housing (and bigger housing) so people move away from the CBD where housing costs are lower and since the income is greater, they are not discouraged by the increased transport cost. Thus, population decreases where *x* is small and increases where *x* is large, decreasing *b*. Secondly, **cheaper and faster transportation** will lead to lower value of *b* because lower values of commuting costs and cost of time spent on travelling will encourage more people to live at greater distances from the CBD where the housing costs are low. Thirdly, it was also suggested that as the urban area grows, the D_0 will increase as will population at each point in the city. Such **city growth** is usually accompanied by an increase in the number of sub centres of production and retailing that can be supported by the urban area. This causes an increase in employment centres which changes the city from a mono-centric model to a polycentric one, thus decreasing *b.* The final relationship discussed by Mills involved the linkages between D_0, *b,* and land value of area just outside the urban area. If the land value of the peri-urban area increased, it would cause a greater number of people entering into the urban boundary. Thus, the overall urban density would increase but this city growth will not cause any decrease in *b.* The relationships discussed above are summarized below:

$D_x = D_0 e^{bx}$ $\quad D_x = D_0 e^{bx^2}$

$b \; \alpha \; \frac{1}{I}$

$b \; \alpha \; \frac{1}{Tc}$

$b \; \alpha \; \frac{1}{R}$ $\quad D_0 \; \alpha \; R$

D_x – Average density at distance x from CBD

D_0 – Average density at CBD

x – Distance from CBD

b – Rate at which the effect of distance attenuates

I – Average Income

Tc – Transport cost

R – City radius

Equation 3. 6 Muth-Mills Density function

3.4.7 J. C. Amson, 1972

By using a simple generalisation of Muth's economic theory of the spatial pattern of urban housing, urban residential density is a direct outcome of housing cost which in turn is a dependent on available land area and available non-land factors. Using this knowledge, Amson laid down fourteen hypotheses describing the cost equilibrium of housing firms and that of households and used these to deduce a theorem showing that if housing demand is elastic, then the dependence of residential density on housing cost follows an exponential relation; a conclusion which agrees with a familiar result obtained by maximising the entropy of a population system subject to a cost constraint, and follows a binomial relation otherwise.

An equilibrium state of housing demand and housing cost is perceived in a state of maximum entropy of the population system and density follows the exponential function in such cases. Amson proposed the quadratic gamma model (Equation 3.7) to model urban density in such cases however it was not supported by empirical analysis.

$$D_x = D_0 x^a e^{(bx - cx^2)}$$

D_x – Average density at distance x from CBD

D_0 – Average density at CBD

x – Distance from CBD

a – Constant depending on population of city

b – Rate at which the effect of distance attenuates

c – Constant measure of rate of change of *b*

Equation 3. 7 Amson's Quadratic Gamma function

3.4.8 Kau & Lee, 1976

Starting from Clark's model and applying Box and Cox's (1964) technique, Kau and Lee proposed two general functional forms in order to describe the relationship between population density and the distance to the city centre. Where β1, β1', β2 and β2' are the regression parameters; λ and λ' are the functional form parameters. Box and Cox transformation was used to transform the independent variable to reduce the model to as simple a form as possible, accompanied by constant error variance and normally distributed observations.

$$\frac{D(x)^{\lambda} - 1}{\lambda} = \beta_1 - \beta_2 u_x + E_x$$

Equation 3. 8 Kau & Lee's density function (1)

D_x – Average density at distance x from CBD

λ, λ' – Functional form parameters

$\beta 1, \beta 1', \beta 2, \beta 2'$ – Regression parameters

$$\frac{D^{\lambda'}-1}{\lambda'} = \beta_1{}' - \beta_2{}' \frac{\left(u_x{}^{\lambda'}-1\right)}{\lambda'} + E_x{}'$$

E, E'– Error terms

Equation 3. 9 Kau & Lee's density function (2)

The appropriate power transformations for Equations 3.8 and 3.9 was determined by iterating λ and λ' between -0.5 and 1.5 at intervals of 0.1.

When λ =1, the density in Equation 3.8 is regressed linearly on distance (Stewart's model). If λ approaches zero, the dependent variable is the natural logarithm of density (Clark's model). Similarly, Equation 3.9 will reduce to the linear form when λ is equal to one, and to a double logarithmic form (Smeed's model) when λ approaches zero. Using data from U.S. urban areas in 1970, Kau and Lee found that λ exceeded zero in 23 out of 40 cases; the density function was between exponential and linear in almost 50% of the cases.

Kau and Lee argue that distance is only one of the important factors determining the density gradient of a city and so density cannot be completely modelled on distance alone, which is why b should not be regarded as a fixed co-efficient. They suggest that b should be the mean value of a random response of population density to distance thus accepting that there are other factors which may cause deviations in this gradient from one part of the city to another, and hence introduced an error term to consider these deviations. The exponential form of this is shown in Equation 3.10.

$$D_x = D_0 e^{b_x x} + E$$

D_x – Average density at distance x from CBD

D_0 – Average density at CBD

b_x – normally distributed random-coefficient estimate of the density gradient, with a mean value equal to the b of the fixed-coefficient model

x – Distance from CBD

E – Error term

Equation 3. 10 Exponential form of Kau & Lee's density function

3.4.9 Zeilinski, 1979

Zeilinski compared seven models of urban population density as shown in Fig. 3.2. The models he studied included the works of Stewart, Clark, Sheratt, Tanner, Smeed, Aynvarg, Muth and Newling and showed the parent of all these functions to be the quadratic gamma function as shown in figure. He tested these seven models along with the equilibrium models of Amson using empirical data of seven English cities.

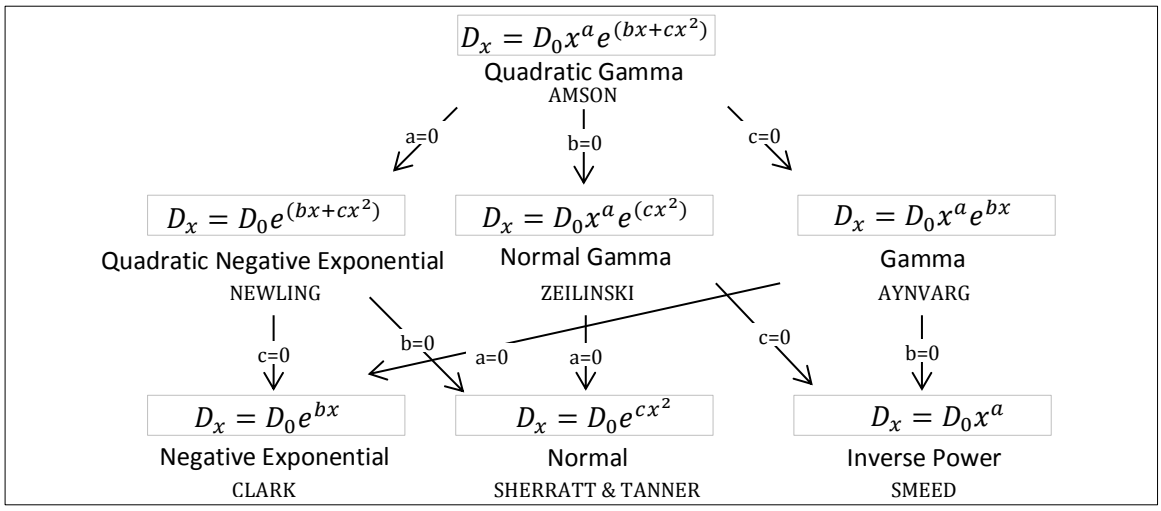

Fig. 3. 2 Quadratic Gamma Models of Urban Density

Figure adapted from Zielinski, K. (1979). Experimental analysis of eleven models of urban population density. Environment and Planning A, 11(6), p. 630.

Additionally, he proposed the "normal gamma model" for modelling urban densities (Equation 3.11). This model is an amalgamation of the inverse-power (which it reduces to, when *c*=0) and the normal function (when *a*=0).

$$D_x = D_0 x^a e^{(cx^2)}$$

D_x – Average density at distance x from CBD

D_0 – Average density at CBD

x – Distance from CBD

a – Constant depending on population of city

c – Constant measure of rate of change of b

Equation 3. 11 Normal gamma function

The maximum density is reached $[a/2c]^{1/2}$ and empirically proved this model to be very effective as it showed higher R^2 value for the fit of the seven cities tested as compared to the other density functions tested on the same data.

3.5 Inverse Power Density Functions

3.5.1 Smeed, 1961, 1963

Parallel to the negative exponential functions developed for modelling urban density, there were also studies on the inverse power function of distance modelling urban density based on the gravitational model of traffic flow in rank size relations. The first model of population density to arise out of such studies was given by Smeed in the 1960s.

The inverse power model was proposed by Smeed (1963) during a comparison of circular

and direct routeing of road traffic using the gravity model. Smeed confined its applicability to "the central area"; his original formulation and its general form are shown in Equation 3.12.

$D_x = \frac{Nx^{-1}}{2\pi R}$	D_x – Average density at distance x from CBD
	D_0 – Average density at CBD
	x – Distance from CBD
	b – distance parameter
$D_x = D_0 x^{-b}$	R – Radius of the city
	N – Total population of the city

Equation 3. 12 Smeed's Inverse Power Function; Original Formulation and General Form

However, the inverse power function has not been as extensively empirically tested as the negative exponential function as the latter proved to be a favourite due to its surprising accuracy and attracted most research and development efforts.

3.5.2 Martin J. Beckmann, 1969

As has been previously established, urban residential density is dependent on residential choice which in turn is a function of the trade-off between commuting distance and rent value. Beckmann discussed that rent being a function of distance from the CBD, and assuming equal tastes and logarithmic utility functions for each of the different income populations, and overall increase of transportation costs proportional to distance, the choice of residences requiring greater commuting distance rises with income. Therefore, rent, density and income turn out to be **power functions** of distance. A simple relationship between city population and total area is also obtained.

3.5.3 Michael Batty & Kwang Sik Kim, 1992

The use of the inverse power function is advocated over the use of the negative exponential function by Batty and Kim (Equation 3.13). They state that a density function should describe the extent to which the space available for urban development is filled, and that theoretically, the inverse power model is the only function that can be used to do this since it is alone capable of representing the fractal property of self-similarity which is considered to be a salient characteristic of the urban form and urban density. They demonstrate that the distance parameter *b* of the inverse power model is a measure of the extent to which space is filled, and that its value is determined by the basic relation *D + b = 2* where *D* is the fractal dimension of the city which changes for cities over time. This model is put to the test using four datasets which measure the density and morphology of the city of Soul. *D* and *b* are estimated using a variety of estimation methods such as log linear regression, dimensional approximation and

entropy-maximising, for 136 variants of the function and its data sets. From these estimates, 125 are within the values hypothesised and this suggests fairly conclusively that the value of *b* for the inverse power function should be within the range 0-1 and probably between 0.2 and 0 .5. Furthermore, the relationship between city size, fractal dimension, changing densities and changing form are explored.

$D_x = D_0 x^{-b}$	D_x – Average density at distance x from CBD D_0 – Average density at CBD
$D + b = 2$	x – Distance from CBD D – Fractal dimension of the city b – Distance parameter

Equation 3. 13 Batty & Kim's Inverse Power Model

3.6 Other Density Models

3.6.1 John F. Kain, 1968

Spatial Mismatch hypothesis was proposed by Kain which speculated that employment opportunities for low – income ethnic minority groups are located far away and are poorly connected to major centres of growth.

After World War I, many wealthy Americans started decentralizing out of the cities and into the suburbs. During the second half of the 20th century, department stores followed the trend of moving into the suburbs. The suburbs started to emerge as the new growth centres with increasing job opportunities. The low-skilled minorities residing in US inner cities experienced poor labour-market outcomes because they were disconnected from these suburban job opportunities. The distance from work centres also lead to increased unemployment rates as well as poverty outcomes for the region at large. This theoretical hypothesis was further investigated in *The Mechanisms of Spatial Mismatch* (2007) by Laurent Gobillon, Harris Selod and Yves Zenou who suggested that there are seven different factors that support the Spatial Mismatch phenomenon.

Kain's hypothesis consisted of 4 main premises:

1. The distance to and difficulty of reaching certain job centres may discourage the minorities from seeking employment there.
2. The minorities may have less information about and less opportunity to learn about jobs distant from their place of residence.
3. Employers located far away from the inner city ghetto may discriminate against the minority groups due to fear of retaliation from wealthy locals of the area.

4. Employers near inner city ghettos may prefer to employ from the minority group hence discouraging them to apply to other places of better opportunity.

These were tested using data of Chicago and Detroit and represented in the form of the Equation 3.14.

$$W = k + \alpha R - \beta d$$

Where,

$$W = \frac{Minority\ workers\ employed\ in\ place\ i}{Total\ workers\ eployed\ in\ place\ i}$$

$$R = \frac{Minority\ workers\ residing\ in\ i}{Total\ workers\ residing\ in\ i}$$

W – Employment Ratio

R – Residence Ratio

d – Distance from Ghetto

Equation 3. 14 Kain's Spatial Mismatch Hypothesis

The R^2 values for these equations were found for various areas, occupations, industries in Chicago and Detroit using which, residential density distribution and its effects on distribution of employment densities of certain minority groups could be explained.

3.6.2 Shirish Patel, 2011

Shirish Patel has proposed several types of "Crowding" which affect the lives of people of an area. These include home or internal crowding (HC) expressed as BUA per capita (built up area per capita), street crowding (SC) which is the number of people using the streets, job crowding (JC), amenity crowding (AC) and open space/ Park crowding (PC) and their relationships are shown in Equations 3.15 a, b and c.

He believes that two factors are responsible for affecting all of these different types of crowding namely, the allowable FAR for various uses in an area, called FSI in India and the built to unbuilt factor, termed as the Plot Factor, or PF. This is the ratio of the built area to unbuilt area.

a. $SC = HC \times PF \times FSI$

b. $SC = HC \times PF_{Home} \times FSI$

c. $SC = JC \times PF_{Job} \times FSI$

HC – Home Crowding (BUA per Capita)

SC – Street Crowding

JC – Job Crowding

AC – Amenity Crowding

PC – Park / Open Space Crowding

FSI – Floor Space Index (Similar to FAR)

PF – Plot Factor (Built to Unbuilt ratio)

Equation 3. 15 Shirsh Patel's Crowding Measures

Patel has plotted all of these factors on a multi-axis graph which can be used as a chart to actively negotiate the trade-offs between each factor. By plotting the FSI, BUA, gross Density, Net Density, and PF of various high density neighbourhoods around the world, these graphs allow one to interpret the trade-offs between building height restrictions, average dwelling area per person and open area available per person in various nations around the world and provides a better structure for their comparison, since the direct comparison of any one of these factors is extremely myopic.

3.6.3 Paul Clarke, Metricity, 2007

Paul Clarke's "Metricity" study (Table 3.1) is based on the premise that the way in which density is measured plays a critical role in the design of an urban area especially in high density areas around transport nodes. While some traditional measures may result in "dead, dormitory-like districts", the right measures to help to create lively and attractive destinations. To support his proposition by quoting Jan-Carlos Kucharek as writing, "The definition of density and how it is measured is important, because interpretations can lead to wildly varying design approaches."

Table 3. 1 Paul Clarke's Metricity Measures

	Measure	Description
1	Intensity	Intensity responds to the changing socio-economic dynamics of an area as a measure of density - and the design implications of its use relate to building typologies. How can we make better use of vertical stacking to create more flexible mixed use developments that combine living, working, retail and leisure?
2	Amenity	Amenity responds to changing household structures and its design implications relate to providing a diversity of housing types with provision of services and open space. How can we provide better living space around transport nodes?
3	Autonomy	Autonomy responds to changing patterns of employment and its policy implications relate to land use, public consultation and zoning. How can we create developments that sustain local jobs and economic activity?
4	Frequency	Frequency responds to changing patterns of movement in the digital city and its policy implications relate to providing new technology infrastructures for a more mobile population.

Starting out by looking at different aspects of London - its historic growth, urban planning controls, employment and development trends, and future plans for transport, and imagining the future outlook and environment with special focus on a high density transport node, London's King's Cross, set to become an international transport hub, was chosen as a research site to play out some of the emerging design scenarios. User participation at the individual, community and local level as well as expert interviews to understand how the local relates to the national and global level, a picture of a vision of a dynamic, multicultural city straining to break free of conventional planning was envisioned.

Various efforts to translate this vision into design interventions in the King's Cross area resulted in four new principles for measuring urban density and supporting a greater animation of dense city development: Intensity, Amenity, Autonomy and Frequency. The definitions of these measures quoting the author are given in Table 3.1. The purpose of these measures was to evaluate and plan for density in a more imaginative way and a way in which it impacts the day to day lives of the urban residents.

3.7 Review of Measures of Urban Density

The urban density models that have been discussed in the three preceding sections have been used to extract the dependent and independent variables used to model density in urban space. These have been shown in Table 3.2.

Table 3. 2 Learnings from Density Models studied

	Name	Independent Variable	Dependent Variable
1.	Clark	Distance from CBD	Gross population density
2.	Tanner	Distance from CBD	Gross population density
3.	Aynvarg	Distance from CBD	Gross population density
		City Population Size	
4.	Newling	Distance from CBD	Gross population density
		Rate of growth	
5.	Muth and Mills	Distance from CBD	Gross population density
		Average Income	
		Transport Cost	
		City Population Size	
6.	Amson	Distance from CBD	Gross population density
		City Population Size	
		Rate of growth	
		Land availability cost	
		Non-land cost	
7.	Kau & Lee	Distance from CBD	Gross population density
		Other factors	
8.	Zeilinski	Distance from CBD	Gross population density
		City Population Size	
9.	Beckmann	Distance from CBD	Gross population density
		Rent	
		Income	
10.	Smeed	Distance from CBD	Gross population density
		City Population Size	
		Radius of the City	
		Traffic Flow	
11.	Batty & Kim	Distance from CBD	Gross population density
		Fractal dimension of city	
12.	Kain	Local Residential Density	Local Employment density
		Distance from Ghetto	
13.	Shirish Patel	Floor Area Ratio	Home Crowding
			Street Crowding

		Built-to-Unbuilt Ratio	Job Crowding
			Amenity Crowding
			Park Crowding
14.	P. Clarke	Mixed-use vertical development	Intensity
		Services and open-spaces	Amenity
		Land-use use, Zoning	Autonomy
		New tech transport infrastructure	Frequency

The dependent variable represents the Density Measure used and the independent variable is the system or unit on which the density was modelled.

3.8 Formulating Density Measures (DM)

3.8.1 Density and Urban Form

Urban density is intrinsically related to a wide range of urban functions and takes a central place in any discussion on sustainable urban forms. The control and management of specific density characteristics has been the focus of idealized urban forms proposed by western planners, right from the Garden City of Sir Ebenezer Howard (1898) to Le Corbusier's Ville Radieuse and F.L.Wright's Broadacre City. In the modern context, the general consensus on sustainable urban form in the western world is that of compact cities. These cities advocate the creation of higher densities through policy, justified by its claims of better social and environmental impacts yet, we see a multitude of urban issues being generated by high population densities in cities of developing countries. Proponents of the Compact City theory maintain that compaction gives rise to greater efficiency in the use of economic, social, physical and environmental resources. This holds true in the developed world where the country dweller relies less on public transport and more on the personal automobile. Additionally, the per capita cost of provision of physical infrastructure and social amenities is greater in the low density areas as compared to dense city cores. However, for developing countries such as India, this theory does not necessarily hold true. The effects of high density which claim to provide economic, social and environmental sustainability are quite different in this case. Firstly, the population residing in cities (other than slum population) is generally richer than those living in the smaller towns/suburbs and hence, has greater access to automobiles and consumer goods and accounts for a greater per capita emission. Furthermore, the highest densities are usually found in areas of geographic vulnerability such as river valleys, mineral deposits or coastal areas due to obvious natural advantages. These high densities therefore concentrate risk in particularly vulnerable locations. Additionally, insufficient infrastructure, inadequate institutional framework and ineffective planning decisions further aggravate these vulnerabilities, often choking natural drainage channels for market driven construction practices or other similar malpractices. More human to

human contact increases the spread of disease in the absence of good public health services and sanitation in high density situations. Under the circumstances, one can therefore not universally advocate the densification of cities, in terms of gross residential density only. What kind of density is being explored and how that density is defined conceptualized and assessed play a very big role in shaping the urban environment. Gross residential density is the most widely used measure of density as shown by the study of urban density models however this single measure cannot capture the various equally important density characteristics that shape an urban environment. It is one among several components of urban form. It can however be proposed that all the other components of urban form can also be expressed and quantified as various layers of urban density measures. Subsequently, if all the parametric qualities of urban form are expressed as quantitative measures of types of urban density, expressing urban form attributes such as building density, open space density, mixed use density, etc., then the urban form could be expressed quantitatively which would allow for empirical studies to be carried out on real cities.

3.8.2 Density and Urban Functions

Apart from urban form, there also exist densities of various functions within cities. Lewis Mumford believed that the city is a system of social functions and to achieve a sustainable urban area, the urban planning of the city should facilitate the many social functions and emphasize an organic relationship between people and their living spaces. This theory further went on to say that the city provides variety and differentiated opportunities for a common life, which define it and afford it greater appeal over country life, even in developed countries where other basic services are of the equal quality. In case of developing countries also, people choose to live in cities in spite of cramped low quality lives because of the wide array of opportunities created by diverse social interaction, such as occupational opportunities, artistic expression, heterogeneous cultures, creative melting pots, dynamic markets and global experiences. The social functions of the city are translated into physical urban areas which fit together overlapping, intersecting or scattered, to form the social areas. The measurement of the density of these social functions is the first step towards the preservation and facilitation of these social systems in planning for sustainability.

It is therefore established that a range of urban density measures need to be constructed in order to comprehensively describe the urban area and capture its many complexities which will then allow effective policy formulation for better urban development.

3.8.3 Multi-layer Measures of Urban Density (DM)

In "Design with Nature", Ian Mc Harg demonstrated the derivation of suitable functional urban zones from the multi-layered super imposition of thematic maps of physical features and natural attributes of specific areas[11]. Following in the same vein, the "Social Atlas of Tokyo" used data of demography, employment, industry, social infrastructure, intensity of various land uses, and land ownership to map and derive "social areas" of Tokyo. The identification of the various areas of different social systems gives great insight into the physical form and functional aspects of the city. Carrying out a similar exercise replacing demographic data with data on urban density would show interesting patterns of physical differentials in the urban form.

1. Physical Measures of Urban Density-

The first layer of urban density measures is based on the quantitative measures of the physical occupation of urban land resource. This is measured using Census data collected at the ward level. This also involves the measurement of household densities, and densities of various functional typologies of buildings in the urban area.

2. Social Measures of Urban Density-

The second layer of urban density measures being discussed can be used to ascertain what lends an urban area its inherent cultural context. The "Metricity" research, done by Paul Clarke, RCA Architecture, focused on formulating new measures of Urban Density. The measures were intended to scope the cultural aspects required to bring environments alive and to animate development around transport hubs. The Metricity study resulted in four new principles: Intensity, Amenity, Autonomy and Frequency. Each of these principles can be modified to present new metrics or dimensions for measuring urban density.

3.8.4 Quantitative Measures for Urban Density

The layers of Urban Density measures discussed so far are expressed as quantitative, as shown in Table 3.3.

Table 3. 3 Urban density measures

Physical Measures of Urban Density
Person/sq.km Households/sq.km Residential area/sq.km Slum area/sq.km Decadal change in population/decadal change in urban area in sq.km

Social Measures of Urban Density	
Intensity	Total built up floor space/sq.km Residential floor space/sq.km Mixed use floor space/sq.km Average road width/sq.km
Amenity	Residential area/sq.km of open space Actual population/ Capacity of (Water, sewerage) Open spaces within walking distance/person
Autonomy	Workers/sq.km Non workers/sq.km. Marginal workers/sq.km Floor space of commercial industrial, mixed uses/sq.km Ratio of residential floor space density/non-residential floor space density
Frequency	Actual population/ Capacity of public transport Daily floating density Ratio of Daytime density/Night time density Peak hour entry point density in Central Business District

3.9 Conclusion

A detailed discussion of various theories of measuring and modelling Urban Density has been undertaken in this chapter. This has helped to clarify three things. First and foremost, the multiple resources and systems existing within a city which shape urban life have been identified and density measures have been formulated based on the people served by each of these resources and systems. This has helped to expand the traditional notion of measuring urban density based on population dependent on urban land resource. Other resources and systems such as employment, basic infrastructure, available open space and available transport capacity have been included to measure urban density, hence achieving the second objective of the research. These measures will be used in subsequent chapters to calculate urban densities in case study cities.

Secondly, various factors on which density is modelled have been identified to understand the factors that affect residential choice and social affordability. It is important to identify these factors because; these are the controls available, for managing urban densities. Finally, a discussion of various mathematical models has helped to understand the way in which urban characteristics may be modelled and how these ideas have changed over the decades as cities have become increasingly complex.

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Chapter 4:

METHODOLOGICAL FRAMEWORK FOR ANALYSIS OF DM AND DI IN STUDY AREAS

"Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody."

— Jane Jacobs

4.1 Need for a Methodology

The overall research methodology for the entire research has been discussed in the first chapter of this thesis and explained as a three stage process (Fig. 4.1). This chapter presents the methodology for carrying out "Stage 2" of the overall research.

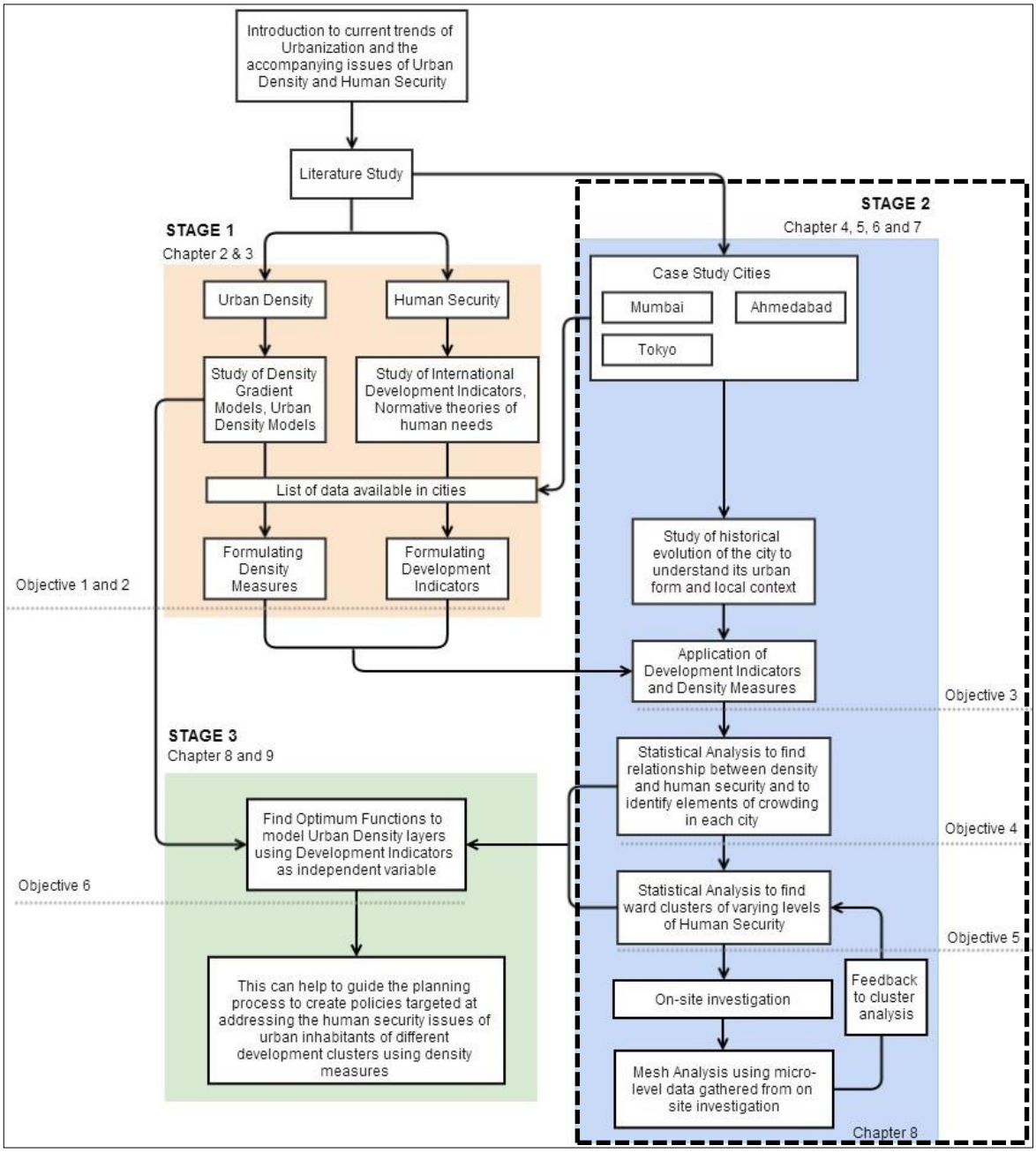

Fig. 4. 1 Methodological framework for Case Studies within the overall research methodology

The first and second objectives of the research have been addressed in the two previous chapters and in doing so, Density Measures and Development Indicators have been formulated

to quantitatively express the levels of various layers of urban density and human security in the wards of the cities being studied (Fig.4.2).

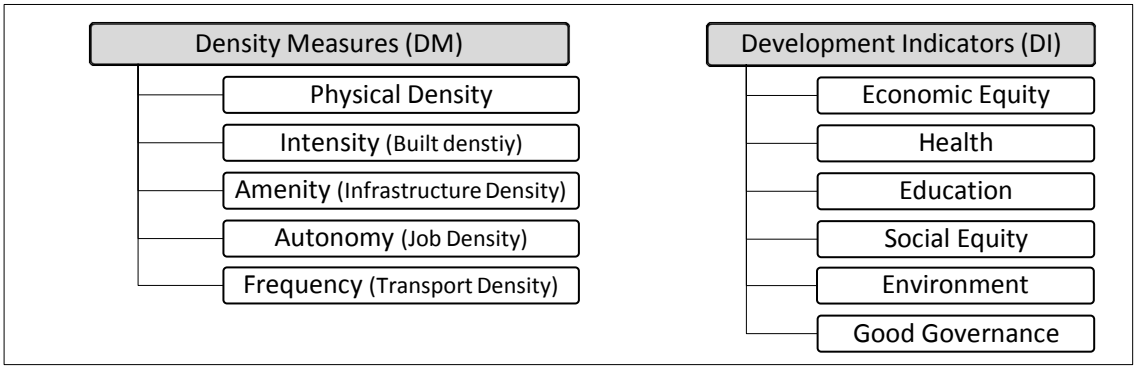

Fig. 4. 2 Density Measures and Development Indicators

The next step of the research calls for an investigation into the **relationship between the DM and DI** present within the cities being studied and see if any similarities exist in these relationships across the cities studied. The analysis of each city must therefore be carried out in an identical manner so that the results obtained are comparable. The methodology used must also be able to successfully capture the contextual aspects unique to each city and adapt accordingly. This chapter presents a methodology which can be applied to each city in order to understand the relationships between its DM and DI.

4.2 Theories of effects of Density on People

There have been several prominent studies to investigate the effects in which people respond to the density of their environment. Several approaches are discussed here, which investigate the effects of density on human behaviour.

4.2.1 Density and Pathology

1. An investigation of the pathological effects of density was carried out using a population of rats by Calhoun (1962).
2. Populations of rats were subjected to spatial constraints and limitations in laboratory conditions. Instead of an exponential growth population because of food, the population suffered a dramatic decrease, exhibiting violent and aggressive behaviour, high infant mortality, a decreased quality of nests and even a lack of nest building exhibited by mothers, cannibalism, and deviant sexual behaviour, followed by asexual behaviour and total withdrawal from the community's social life. These were together coined as "behavioural sink" and Calhoun warned that the same effects would also be seen in human populations.

3. Successive studies have indicated that although the absolute amount of space available to rats does not have conclusive pathological effects, the increased interactions and the loss of control over those interactions that are brought about by increased density; do induce stress and cause deviations from normal social behaviour.

4.2.2 The theory of density-intensity

1. The psychologist Jonathan Freedman (1975) conducted a lab research on people in which his subjects were asked to perform different tasks under different density and crowding conditions.
2. His work showed that crowding; brought about by excessive, uncontrollable social interactions; rather than density, is responsible for the degenerative behaviour of populations.
3. He sets out *the theory of density-intensity* which supports the idea that crowding increases the importance of other people to the situation, as "[...] crowding by itself has neither good effects nor bad effects on people but rather serves to intensify the individual's typical reactions to the situation".
4. His work supports the fact that density alone does not have negative effects on humans, but it intensifies the typical reactions towards other people involved in the crowding situation.

4.2.3 Effect of Designed spaces on human behaviour

1. The design of spaces has a great effect on the kind of interactions the inhabitants are subjected to, and the amount of control they exercise on these interactions.
2. One of the first sociological studies that relate the design of spaces to human behaviour was carried out by Andrew Baum and Stuart Valins (1977). Their study compared the behaviours of two similar groups of students that lived in two different types of dormitories, with different planimetric layouts.
3. In one type of dormitories, the bedrooms were organized along one single hallway which exposed its residents to a high level of interactions with a very large number of people.
4. In the other type of dormitory four or six person suits were arranged along one central hallway, which allowed the residents to limit interactions within a small group of people.
5. The results of the study showed that students that lived in the corridor-design dormitories, had developed a greater sensitivity to group size and a lower tolerance towards crowding. In order to cope with the large number of unregulated social interactions, they became withdrawn and avoided social interaction.

4.3 Theoretical Relationship between DM and DI

As seen in the density gradient models studied in Chapter 3, the Urban Density Measures are affected by several urban aspects and have a significant effect on the choices urban residents make. Some of the aspects that affect the density measures are distance to CBD (Clark, 1951; Tanner, 1961; Aynvarg, 1969; Newling,1969; Muth & Mills,1969; Amson, 1972; Kau & Lee, 1976; Zeilinski, 1979; Smeed, 1963; Beckmann, 1969; Batty & Kim, 1992) , city population size (Aynvarg, 1969; Amson, 1972; Zeilinski, 1979; Smeed, 1963), trip length/expense for work (Muth & Mills,1969; Kain 1968), open space ratio (Patel, 2011; Clarke, 2007;), etc., all of which have a significant effect in the residential choice, employment density, built intensity, infrastructure availability and transportation density of the urban area. These density measures consequently have an effect on the lives of urban inhabitants of different social and economic affordances. Although many of the early density models had assumed that all of the urban inhabitants had similar annual earning and uniform tastes, which was essential for the modelling of urban residential density based solely on the trade-off between housing cost and transportation cost, such assumptions are not feasible in reality. The realistic urban space consists of a wide variety of people who belong to a huge range of social, economic, ethnic, and other groups. Individuals and families from these groups respond differently to the constraints presented to them by the urban density measures. The choices these individuals make, in aggregation, form the social areas of the city.

The DMs are the fundamental **elements** of urban density that exist in urban space which can be measured quantitatively. Several urban **relations** such as land rent, travel cost, etc., affect the DMs and their interaction with urban space and these have been used for modelling urban density as seen in the density models studied. The end users of the urban space; the urban inhabitants are affected by the elements as well as the relations. The socio-economic background of the urban inhabitants affect the way in which they respond to the elements and relations and the subsequent **systems** they create in the urban area by virtue of the place and manner in which they choose to live and work (Corbusier, 1973). This choice which creates urban systems also reflects the social areas within a city and largely represents the different groups of people living with different levels of human security (Fig. 4.3). The DMs described in the categories of elements, relations and systems and possible ways in which crowding can occur leading to lowering of DI, have been presented in Table 4.1.

The elements, relations and systems which relate DM to DI are also similar to the three interacting levels of network operators distinguished by Dupuy in 1991 where the 1st level operator includes the technical networks such as roads, common transport, telephone

networks, etc., the 2nd level operator includes the functional networks and the 3rd level operator is made up of the specific network/territory of each urban household. The users of functional networks make selective use of the technical networks for their specific purposes optimized for each in unique ways therefore creating their own virtual city starting from their home location and based on time-space budgets. These virtual cities are therefore a reflection of the capabilities afforded to the residents by the interaction of the city's technical and functional networks. If these interactions prove favourable, citizens are satisfied with their capability, resulting in a high level of human security. However, if the virtual network of a household or community is not satisfactory, then that group of people feels insecure and socially excluded especially in the presence of other more capable groups. Many social stresses may already be present within the populace however, crowding intensifies the stresses and hence has an adverse effect on the lives of urban inhabitants. The control over social interactions discussed in the theories of how density affects human behaviour, can be one aspect of insecurity. An individual's control over various aspects of their day to day lives determines their capability and defines the human security of that individual.

It can therefore be said that although absence of crowding cannot ensure security, the presence of crowding, with existing social stresses, does ensure insecurity. Finding areas of varying levels of human security within an urban system and investigating the crowding characteristics of that system can therefore help to identify the density problems within that city. This can be done by measuring the DIs and regressing composite value with all of the DMs, to see how the DMs together affect the composite DI and what role is played by each DM in this relationship. The DMs with maximum positive and negative effect on DI can therefore be identified for each city, which can indicate the steps to be taken in managing the various densities for the overall development of the people of the city by reducing the debilitating factors of crowding.

Some of the situations caused as a result of crowding such as slums, low liveability, high real estate value, high crime, etc. are listed in Table 4.1. These are also indicators of a low human security which is measured using the different parameters of economic equity, health, education, social equity and good governance as DI. DM is therefore closely related to DI because low DI is often correspondent to crowding of various city functions. However, the nature of crowding and the elements which cause it are different in each city and clusters within cities. Studying the relationship between the DI and DM in various cities can help to reveal which of the DMs are factors of crowding in each of the individual cities studied.

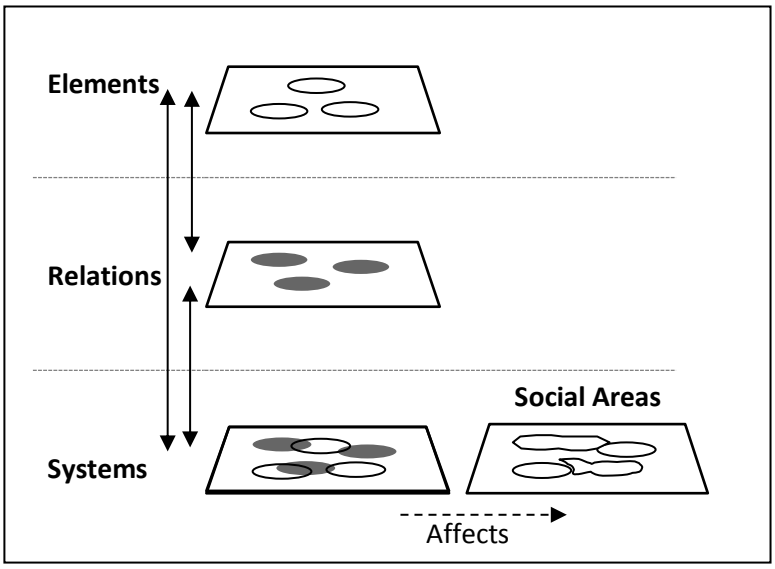

Fig. 4. 3 Elements, Relations and Systems in the city

If the DM elements and the relations are able to adequately provide for a household or community, then there is no crowding of DMs, and as a result the chances of that household or community feeling deprived, is reduced. This however does not automatically ensure a high level of human security because the DMs are not the only factors which cause capability deprivation. There are very many social stresses which may already be present within the populace as the causes for capability deprivation as stated by Freedman's Density-Intensity Theory. In the Density-Intensity Theory of Crowding (Freedman, 1975), Freedman proposes that "Crowding by itself has neither good effects nor bad effects on people but rather serves to intensify the individuals' typical reactions to the situation." It is important to note that this theory does not say that high density has no effect on humans. Instead, it states that since density itself does not cause any specific reaction (it only intensifies reactions) no predictable behaviour can be expected from a group of people at specific density. The reactions would essentially be caused by environmental, social, and personal characteristics of the subjects which may be intensified by the increase in density.

Following from the above discussion, crowding intensifies the stresses and hence has an adverse effect on the lives of urban inhabitants which may cause a loss of control and therefore lead to insecurity. The study of "Proxemics" (Sommer, 1967) demonstrates that people do respond to the space they share with others, with the response varying with culture, gender and other factors. There are several other conceptual approaches to crowding such as; social overload which talk about too much social stimulation, behaviour constraint dealing with reduced behavioural freedom, ecological theory of scarcity of resources (Stokols, 1976), unwanted interaction (Baum & Valins, 1977) addressing undesirable contact, interference

(Schopler & Stockdale, 1977) about disruption of goal directed behaviour and privacy regulation (Altman, 1975) dealing with the inability to maintain desired privacy, all of which can be subsumed by the concept of **control**. It is therefore understood that the **negative effects of crowding felt by people are only caused by the feeling of loss of control over their environment, privacy, interactions and resources** (Bell *et al*. 2006). The need for maintaining control can be equated to a state where the individual feels that external sources cannot disrupt their decisions, actions and ambitions. It is therefore quite similar to the concept of capability deprivation and having 'freedom from want', 'freedom from fear' and 'equal opportunity' which form the cornerstones of human security. Therefore, a satisfactory level of control can be equated to optimum human security, and the effects of crowding disturbing it can be investigated. The level of control over one's surroundings and the level of importance associated with it vary greatly depending on an individual's financial status, social habits, and cultural background.

It can therefore be said that although absence of crowding cannot ensure security, the presence of crowding does ensure insecurity. Finding areas of varying levels of human security within an urban system and investigating the crowding characteristics of that system can therefore help to identify the density problems within that city. This can be done by measuring the DIs and regressing their composite value with all of the DMs, to see how the DMs together affect the composite DI and what role is played by each DM in this relationship. The DMs with maximum positive and negative effect on DI can therefore be identified for each city, which can indicate the steps to be taken in managing the various densities for the overall development of the people of the city by reducing the debilitating factors of crowding.

The DMs described in the categories of elements, relations and systems and possible ways in which crowding can occur leading to lowering of DI, have been presented in Table 4.1. Some of the situations caused by crowding are, overcrowding, slums, low liveability, high real estate value, high cost of living, high crime, traffic bottlenecks, high air, noise, water pollution, susceptible to natural hazards, low infrastructure per capita, wide socio-economic gap. These are also the indicators of a low human security which is measured by DI. In general DM is therefore related to DI because low DI is often correspondent to crowding. However, the exact nature of crowding and the elements which cause it are different in each city and clusters within cities. Studying the relationship between the DI and DM in various cities can help to reveal which of the DMs are factors of crowding in each of the individual cities studied.

Table 4. 1 Elements, Relations and Systems of Crowding

Density Measures			Crowding Situations
Element	**Relation**	**System**	
1. Physical Density			
Slum density, population density, household density	Rent, health, development policy	Gentrification, sprawl characteristics, urban boundary	People living in extremely high density situations such as in slums without personal space and in unhygienic conditions. High land rent also causes wide separation of socio-economic classes.
2. Intensity			
Built/unbuilt ratio, size of tenements, availability of open spaces	Building regulations, FSI/FAR, Special planning areas	Residential choice of social groups, locational choice of different industries	High built up intensity leading to absence of open spaces and increasingly small sizes of tenements leads to gentrification, thus increasing crime in inner city, increased pollution due to increased daily in-migration and pressure on existing infrastructure.
3. Amenity			
Technical Network - Water supply, Electricity, Sewerage, Telephone lines	Functional Network – City level Production and consumption function	User Network – The physical and social affordances of each household or company in utilizing the technical and functional networks	Crowding for basic amenities such as water supply, sewerage, electricity caused due to population growth outpacing capacity building of infrastructure systems and social amenities.
4. Autonomy			
Number of jobs suitable to local skill sets, jobs close to residence	Zoning – Primary, Secondary, Tertiary industry and administrative machinery	Formal and Informal economy interdependencies, agglomeration economies.	Labour supply exceeding jobs leads to crowding for jobs, lowering of cost of labour, informal activities, corruption and crime. Also, travelling for job puts pressure on transportation.
5. Frequency			
Capacity of public transport, traffic volume	Major O-D points, cost of travel	Modal choice, average trip length, trip time, primacy of central area.	Commuters exceeding transport capacity causing inefficiency and overcrowding. Long trip lengths also related with high housing cost in node.

4.4 Methodology for studying the Urban Density characteristics corresponding to social areas of different Human Security

A five step methodology was constructed to understand the crowding parameters of each city to which it was applied (Fig.4.4).

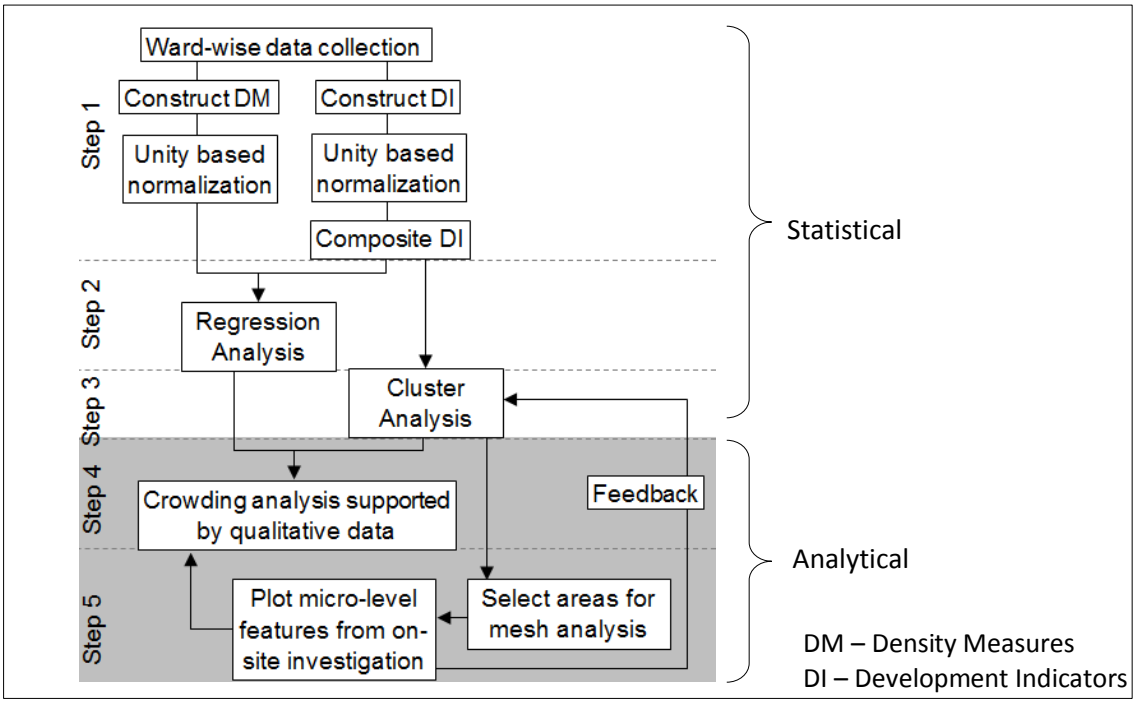

Fig. 4. 4 Methodological Framework for analysing case studies

The **first step** was to collect data from case study cities and suitably apply the DI and DM to these data to statistically measure Human Security and Urban Density for statistical analysis. This was done at the ward-wise level because data for smaller spatial units was not available especially in cities of developing countries. A unity based normalization was applied to make the various datasets comparable across the wards and the composite DI for each ward was calculated by taking the mean of the normalized values.

The **second step** was to analyse the relationship between DI and DM at the macro ward-wise level using multiple-regression analysis. The composite DI was taken as the dependent variable and each of the DM were the independent variables. The regression analysis provided an equation with which composite DI varied as a function of DMs across the wards of each city. This could be interpreted to understand the DMs that affected DI positively and those that posed as a limitation. Insufficiency of the positively related DMs and abundance of the negatively related DMs would result in crowding. The respective weightage of each DM within the regression equation could also be interpreted from this analysis.

A cluster analysis was done in the **third step** using DI as the clustering variable, to plot the spatial pattern of levels of DI clusters present in the city. This revealed spatial patterns governing the social areas of each city which were closely related to its historical socio-economic structure.

The results from step 2 and 3 helped in identifying the crowding situations in each city and the DM causing it. In the **fourth step**, literature reading was done to support the quantitative

analysis which helped to understand the existing land use characteristics and evolution of the spatial, social, political and economic systems of the city which further helped in analysing and understanding the crowding situation. The ward-level analysis gave interesting insights into the density and security characteristics of various parts of each city. However, ward boundaries are administrative boundaries and socio-economic factors usually have no role in delineating or impacting individual wards in individual ways. This makes it unlikely that the actual spatial boundaries of social areas correspond to ward boundaries. It is also impractical to assume that each ward has uniform DI across its entire area.

A micro-level analysis of the variations within wards was done through on – site investigation and mesh analysis. This forms the **fifth step** of the methodology. On – site investigation revealed various grades of housing which were mapped onto a grid of cell sizes of 500m x 500m superimposed on the wards of different DI levels selected from the cluster analysis. The housing grades were assumed to be representative of the economic status of the households and so, areas of varying economic security could be identified at the micro scale. The percentages of various Housing Grade cells were calculated to confirm the results of the macro-level cluster analysis. Furthermore, intensity characteristics such as percentage of built up land and average number of floors, were also plotted on the grid. This helped to identify the typical residential blocks of various intensity and socio-economic characteristics prevalent across the city and see how the macro level analysis results translate onto the micro level. Methodology for Statistical Analysis of Case Study Cities

The steps 1, 2, and 3 described in the previous section constitute the statistical analysis of data obtained for each of the case studies. These steps are detailed in this section and showed in table 4.2.

Table 4. 2 Methodology for Statistical Analysis of Case Study Cities

Question Number	Step name	Question asked	Data used	Description
	Introduction	Where is the city? What is its urban history and character?	Land use, City development plans	City location and brief urban history
1.	DM and DI of the city	What are the DM and DI of the city?		Data collection for computing DM and DI
2.	Exploratory Analysis of Relationships between DM and DI	Do the datasets for DM and DI have a relationship?	DI – Economic Equity, Health, Education, Social Equity, Good Governance DM – Physical density, Intensity, Amenity, Autonomy, Frequency	Preliminary exploratory analysis – scatter graphs, Pearson's correlation coefficients
3.	Regression function of DM and DI	What is the relationship between the datasets for DM and DI?	Dependent variable – Composite of DI, Independent variable – Physical density, Intensity, Amenity, Autonomy, Frequency	Analysis to find the relationship between DM and DI – Multiple Regression Analysis
4.	Cluster Analysis using DI	What are the areas which need urgent intervention due to having lowest level of DI?	Composite of DI	Cluster Analysis of DI using Ward's method.
5.	Inter-cluster variations of DI datasets	What DI characteristics define these clusters??	Data used to compute DI such as % of population residing in slums, unemployed population, females per 1000 males, % literates, % assisted households, female employment ratio, crime rate, pollution complaints.	Observing how data representative of the DI, such as % of population residing in slums, unemployed population, females per 1000 males, and literates, varies across the 5 clusters.
6.	Variations in DM datasets corresponding to DI clusters	What DM characteristics do these clusters correspond to?	Data used to compute the DM such as sewerage coverage, water supply coverage, local employment ratio and gross population density, floating density and net built density.	Observing how data representative of the DM, such as sewerage coverage, water supply coverage, local employment ratio and gross population density, varies across the 5 clusters.

4.5 Conclusion

A methodology for analysing the DM and DI characteristics of case study cities has been outlined, and a statistical methodology to be applied to each, has been explained (Fig. 4.5).

Since this is intended for the analysis of all the cities studied in the research, the analytical steps have been limited to make it widely applicable. The steps have been formulated to answer six questions that are used to understand the relationship between DI and DM in each city and the characteristic features of each. The research objectives 3, 4 and 5 are achieved as a result of this statistical analysis. The following three chapters of this thesis (Chapter 5 to 7) will follow this statistical methodology for the three case study cities.

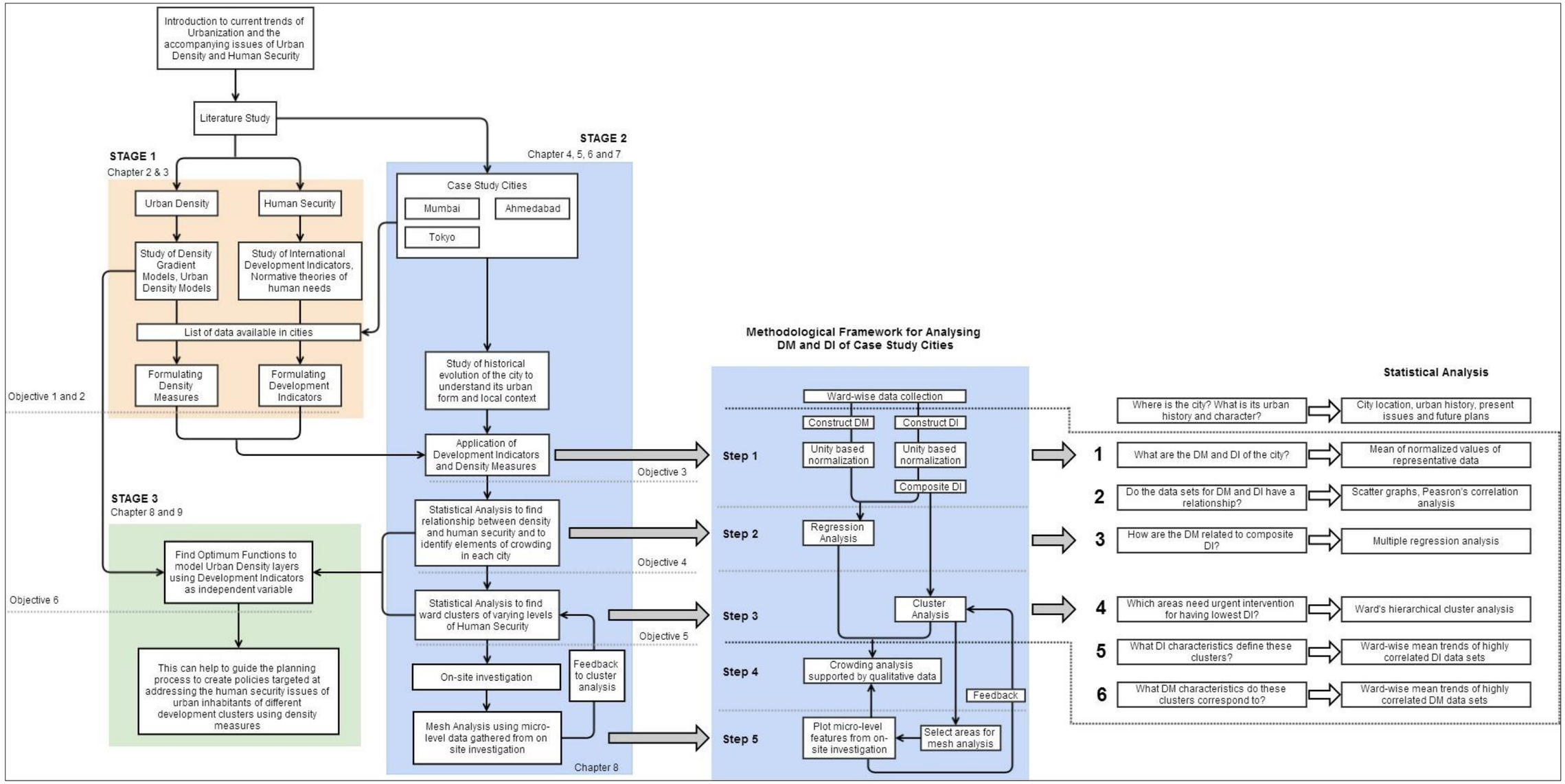

Fig. 4. 5 Methodology for exploring the relationship of Urban Density and Human Security

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Chapter 5:

STUDY AREA: MUMBAI

"What comes across clearly is that Mumbai is burdened with numbers; and that numbers are its strength"

- *Mumbai HDR 2009*

5.1 Introduction to Mumbai and its Urban History

Mumbai, known as Bombay till 1996, is the capital of the western Indian state of Maharashtra (Fig. 5.1) located at 18˚58'30"N 72˚49'33"E. The study focuses on the 24 wards that make up Greater Mumbai (the 9 southern wards forming the Mumbai City District and the 15 northern ones forming the Mumbai Suburban District) which is 438 sq.km in area and has a population of 11.98 million (Census 2001) and forms the core of the much larger Mumbai Metropolitan Region.

The city suffers from the pressure of land scarcity leading to extremes of high density as it is geographically landlocked by the sea on the west, south and east. Growth is therefore limited to the north only and is largely dependent on the linear rail linkages connecting the economic nodes of the city in the south with the residential areas in outer suburbs in the north.

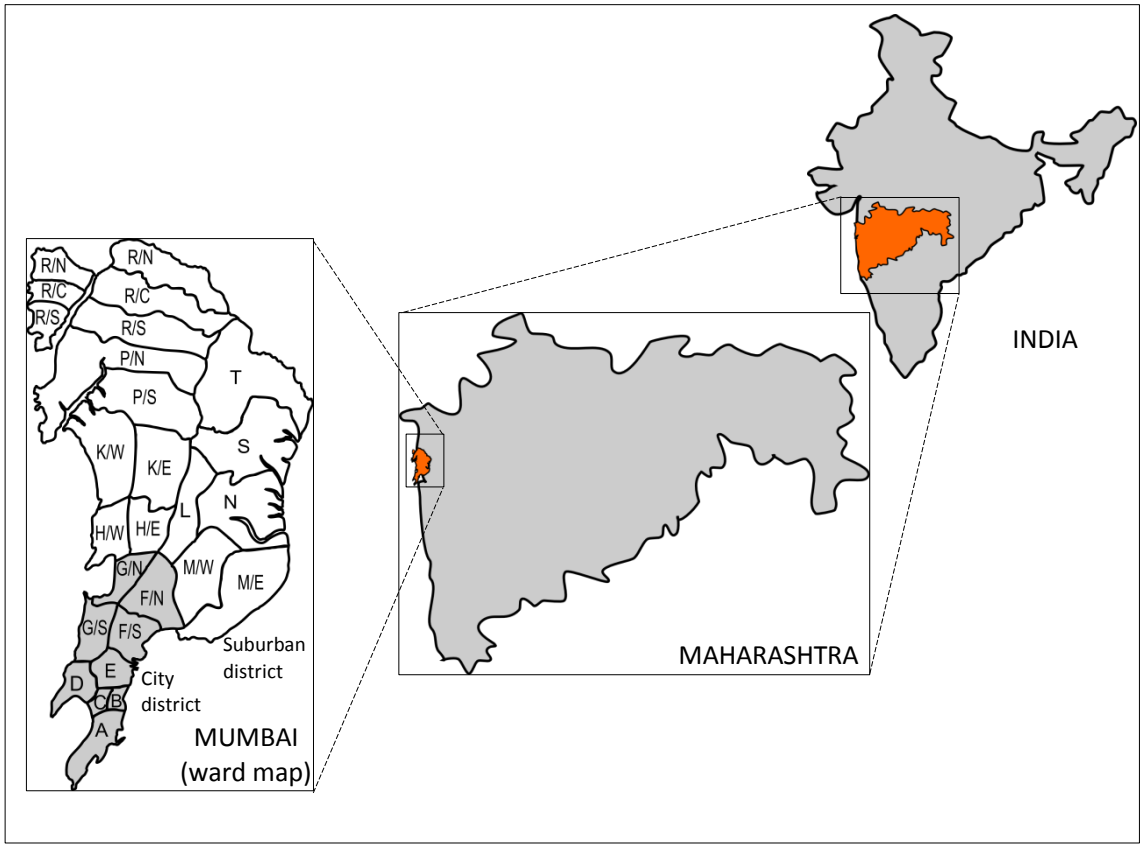


Fig. 5. 1 Location of Mumbai in Maharashtra, India

5.1.1 Evolution of Physical Profile of Mumbai

The southern part of Mumbai called the "Island City" which makes up wards A, B, C, D, E, F/S, F/N, G/S and G/N were originally a cluster of seven islands of volcanic origin (Development Plan, 1981) as shown in Fig. 5.2. Evidence has shown that these islands had been inhabited

since the Stone Age. The seven original islands proceeding from south to north were; Colaba, Old Woman's Island, Bombay, Mazagaon, Worli, Parel and Mahim. These names were given by

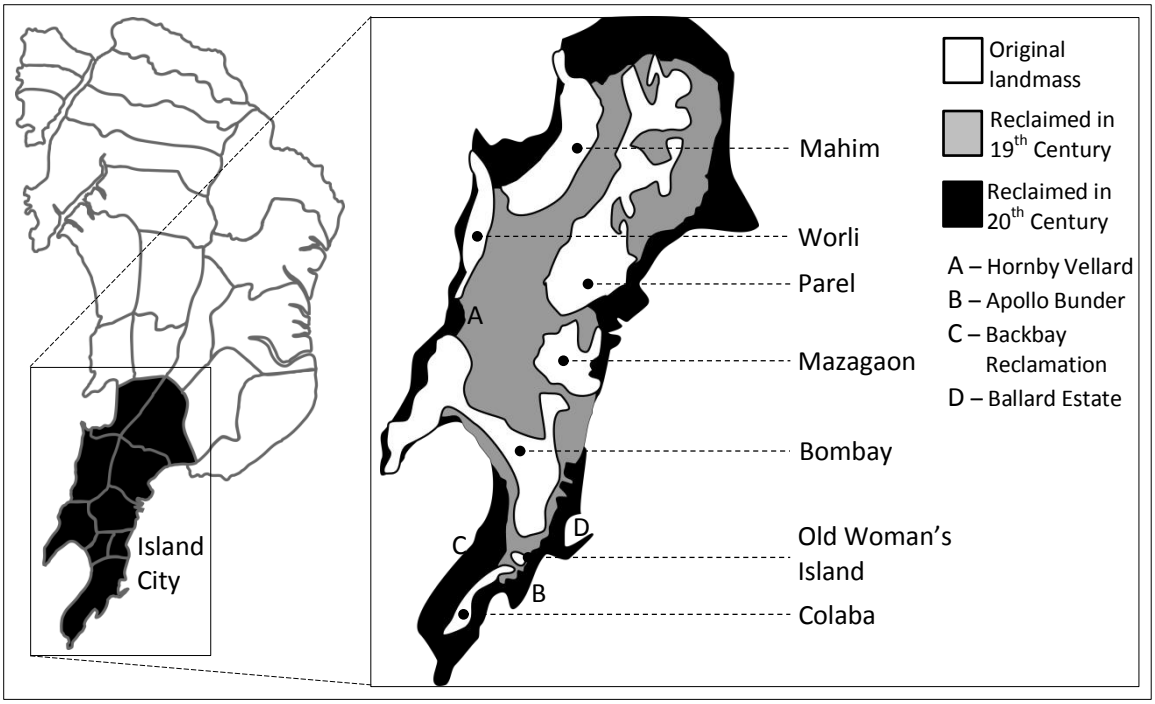


Fig. 5. 2 Mumbai's history of land reclamation

the Portuguese and were corruptions of the local names given by the original settlers of the area, who were predominantly the *Koli* fishermen.

By the 1700s, the islands were under the control of the British East India Company who, from the 1760s, encouraged speculators to control breaches at the points where the sea overflowed the seven islands. Thus began the initial idea of physical unification. This led to one of the earliest reclamation works when the Hornby Vellard was constructed between Mahalaxmi and Worli in the 1770s marked as "A" in Fig. 5.2.The large scale moulding of the islands into one landmass began in 1836 with the founding of the "Elphinstone Land Company"; Bombay's first reclamation company. The creation of the Colaba causeway in 1838 connected the southern island of Colaba with the rest of the islands.

In 1853, India's first passenger railway line was established connecting Bombay to the neighbouring town of Thane. Bombay was the world's chief cotton trading market at the time (owing in part to the American civil war in 1861 – 1865) resulting in an economic boom. The 1860s saw a surge in reclamation and development of the foreshores of the island on both the eastern and western sides funded by the large influx of wealth brought in by its success as a commercial centre. The opening of the Suez Canal in 1869 further enhanced the city's economic stature and transformed it into one of the largest seaports on the Arabian Sea.

The Bombay Port Trust was established in 1873, which set about reclaiming land for port building activities. 1880 acres of land were created by this agency (Mehrotra, 1991). The Port Trust continued to reclaim land over the next four decades, the most important being the Apollo Bunder and Back Bay reclamations ("B" and "C" on Fig. 5.2). These in particular significantly transformed the urban landscape to give it its present identity. Each of these reclamations strived to create a symbolic sea facing identity as shown in Fig. 5.3

Fig. 5. 3 Iconic areas of Mumbai constructed on reclaimed land
Top left-Apollo Bandar, Top right-Nariman Point (Backbay reclamation), Bottom left–Marine lines (Backbay reclamation), and Bottom right-Horniman Circle (Ballard Estate)
Image source clockwise from top-left: Q T Luong 2007, taken by author in 2013, wonderfulmumbai.com, India Guide.

The major land reclamations had already been completed until the early 1900s. India gained Independence from the British Empire in 1947 after which the city saw massive expansion. This expansion was majorly towards the mainland of Maharashtra except for the incomplete Backbay reclamation scheme. The then Mayor of the city Mr. F. P. Nariman, who, with the help of public opinion, brought a stop to the reclamations which had been plagued by scandals and irregularities for the previous couple of decades. Several successive committees furthered this opinion. However, these warnings were ignored and the last phases of the Backbay Reclamation scheme were completed in the 1970s.

5.1.2 Evolution of Socio-Political Profile of Mumbai

Mumbai has undergone radical changes of political power as different communities have been at the helm of affairs over its history, as shown in Fig. 5.4. Originally a group of seven islands inhabited predominantly by *Koli* fishermen communities and some potters who used the marshy soil to make earthenware, the administrative unification of the area as one entity

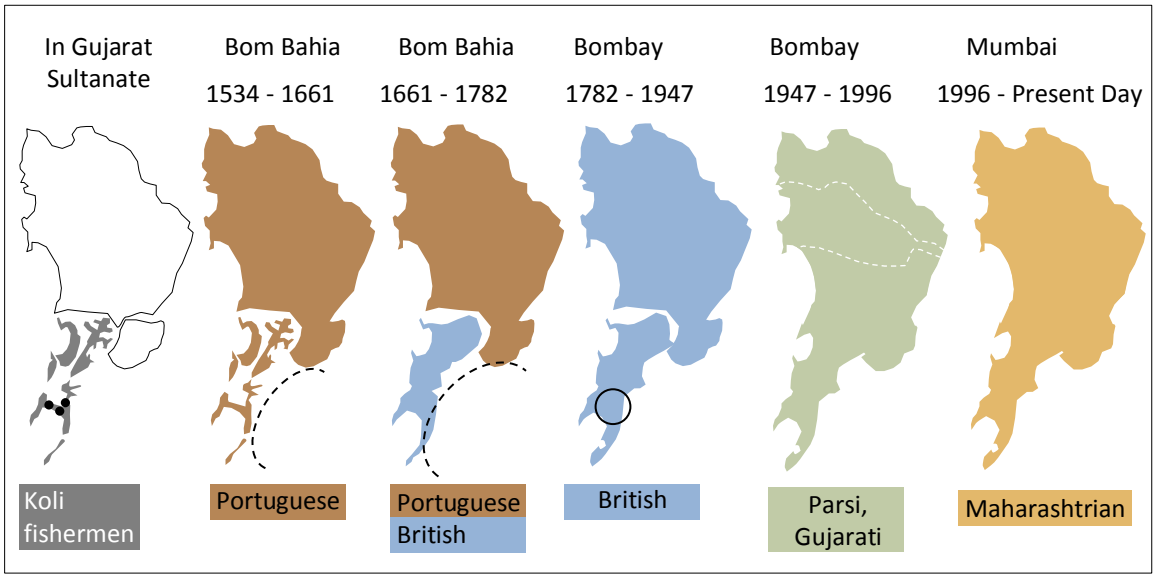


Fig. 5. 4 Timeline of Political History of Mumbai

happened with the arrival of the Portuguese. The dominant power of the Indian subcontinent in the 16th century was held by the Mughal Empire including the Gujarat Sultanate under which the seven islands fell. However, the Portuguese forced Sultan Bahadur Shah, the ruler of the kingdom including present day Mumbai, to sign a treaty and hand over the seven islands and nearby strategic town to the Portuguese, in 1534 and later surrender the area to the Portuguese in 1535.

The large H - shaped island called Bombay (see Fig. 5.2) formed one of the administrative divisions of the Portuguese capital at Vasai (Bassein), north of Salsette and was the site for a large Portuguese manor. The Portuguese called Bombay "*A ilha da boa vida";* the island of good life (Dwivedi & Mehrotra, 1995) and named it *Bom Bahia* which meant “Good Bay”.

In 1661, the island of Bombay and those to its south were gifted to King Charles II of England by the King of Portugal as a dowry for marrying the Portuguese princess, Catherine of Briganza. The northern areas of Salsette, Mazagaon, Worli, and Parel were however retained by the Portuguese due to which the area very much remained under the Portuguese influence. The British continued their efforts to claim the islands. King Charles II gave Capt. Humphrey Cook the charge of Bombay in 1665 who decided to fortify the large Portuguese manor on Bombay, and christen it as the Bombay fort. Three years afterwards, in 1668, the islands were leased to

the British East India Company which sealed Mumbai's fate as an important trade city. The islands were identified as a strategic base for trade and were repeatedly attacked by the Siddi Mughals and Dutch invaders.

In 1687 the British East India Company transferred its headquarters from Surat to Bombay and placed the city at the head of all the Company's establishments in India. The islands were developed as a centre for trade and commerce offering various incentives for businesses and hence attracting various communities such as Gujaratis, Parsis, Bohras and Jews. The Portuguese presence in Bombay ended when the Marathas captured Salsette in 1737 and Vasai (Bassein) in 1739. However, these areas were later captured by the British and in doing so, the British attained administrative power over the entire geography of present day Greater Mumbai area by 1782.

From 1782 onwards, large scale civil engineering works aimed at merging the entire landmass into one entity were embarked upon as discussed in the previous section. The Bombay Presidency under the British came to include much of western and central India and parts of Pakistan. As the capital of the Bombay Presidency, the city of Bombay was an important venue for the Indian Independence movement and was the site of the "Quit India Movement"; a civil disobedience movement launched by the All-India Congress Committee initiated by Mahatma Gandhi.

After India's Independence in 1947, the territory of the Bombay Presidency except for the parts that now belonged in Pakistan was restructured into Bombay State with the city as its capital. At this point, Gujarati industrialists were at the strongest positions in Bombay and were in favour for it to be an independent state. However, there was a movement to create a separate state of Maharashtra with Bombay city included within its boundaries, by the Marathi speaking population. In 1960, the Bombay state was split along linguistic boundaries. The Gujarati speaking area was partitioned into the state of Gujarat and Maharashtra state was formed with Bombay as its capital.

Although Bombay constituted a very heterogeneous demography, local political pressures have been pushing for a more homogenous populace of Maharashtrian origin. This has led to several conflicts between the Maharashtrian people and the large number of migrant population from northern India. In a bid to strengthen their claim to the city, the name "Bombay" was reported to be a British corruption and was changed to "Mumbai" in 1996 which is the name of the city in the Marathi language. The governance of Greater Mumbai is now under the Shiv Sena party who are the Marathi-Hindu extremists, although the city boasts a very mixed composition of population.

5.1.3 Evolution of Economic Profile of Mumbai

Mumbai is the financial capital of India contributing about 5% of its GDP and has always enjoyed a distinguished position for its high productivity. Its utility as a strategic base for trade was identified by the Portuguese settlers of the city who used the sheltered bay on the eastern coast to harbour ships.

The island was presented to Prince Charles II for his marriage with the Spanish princess but the crown did not want it because of the swampy and inhospitable nature of the area. The merits of this swampy area as being good for growing cotton was however recognized by the British East India Company who acquired it on a very inexpensive lease in 1668. The Company fortified the city in 1717 thus separating the southern islands inhabited by the British, from the northern area inhabited by the native people. Mumbai was not envisioned to be a large city, but rather a port town to act as a node for trade links with India, which is why an organised plan or singular image was not conceived for its construction (Dwivedi and Mehrotra, 1995; Swaminathan and Goyal, 2006).

The city continued to grow as its importance as a trade town and cotton manufacturing centre increased. During the American Civil War Bombay became the prime area for cotton production and many cotton mills opened in the city. The Bombay Spinning and Weaving Company was the first cotton mill to be set up in Tardeo, Mumbai, in 1856. The opening of the Suez Canal in 1869 and the completion of the Bombay – Delhi railway line in 1872 furthered Mumbai's importance. A boom in the textile industry followed, with 10 cotton mills set up in Mumbai by 1865, employing over 6,500 workers which increased to a total of 136 mills being set up by 1900. The textile industry was offered added government incentives in the form of long term leases (some of 999 years), as mills stimulated the economic growth and employment (D'Monte, 2006). Land reclamations facilitated this growth and made land available for incremental development. The success of the textile industry created a pool of wealth not only among the British, but also among the Indians. The mills were owned by former traders such as the Tatas, Petits, Wadias, Currimbhoys, Thakerseys, Sassoons, Khataus, Goculdas, Cottons, and Greaves. The mass of wealth was channelled into rebuilding the core, reflecting the city's wealth in the most ornate architecture of the time. The previously constructed Bombay Fort walls were demolished in 1862 as they were a hindrance to the growth of the city which did not need fortified protection anymore.

Most of the mill workers came from areas around Mumbai and the *Kolis* were particularly represented. The mill owners housed their workers in *chawls* built in the areas of Girangaon (literally "the village of mills"). At their peak in 1980, the mills employed 300,000 workers.

However, the mills were permanently closed after the Great Bombay Textile Strike of 1982, which went on for 18 months at many mills and triggered the end of the struggling industry, with most of the mills being shut down after the strike. This was followed by a decline in other industries such as heavy engineering, pharmaceutical companies, and fast moving consumer goods companies.

The economic liberalization of India in 1991 brought with it an environment of globalization. Over the past two decades, the service industry in Mumbai, particularly financial services has grown and contributed to its growing economy. The new foreign companies, focussed on financial and producer services, are concentrated in the Nariman Point area. This area forms an important node in the production system of multinational companies connected by a global network due to which it gets the name "Global CBD" (Grant and Nijman, 2002:16). The Fort area which had developed as the CBD in the colonial era, and is now home to the headquarters of major banks and national institutions, is called the "National CBD", while the *Kalbadevi* area, with a "Bazaar" atmosphere corresponds to the "Local CBD" (*Ibid)*. However, since the skills required in this sector are extremely specialized, only a handful of highly skilled professionals stand to gain. The large masses of low-skilled workers who lost their jobs after the mills shut down and also the migrants who come from other parts of India in huge numbers, have neither proper employment to absorb them, nor adequate housing. This has led to a growing divide between the urban elite and the urban poor (Sassen, 1991), accompanied by a growth in the informal economic sector. The stages of Mumbai's economic history discussed in this section are summarized in Fig. 5.5.

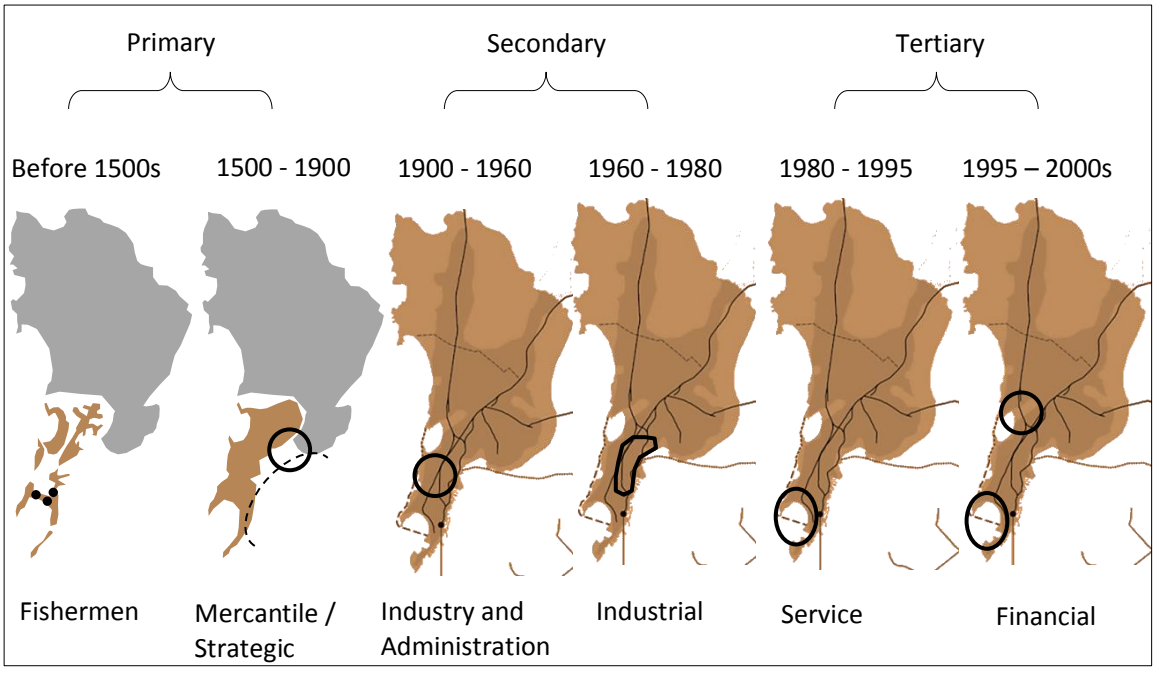


Fig. 5. 5 Timeline of Economic History of Mumbai

5.1.4 Population Growth and Slums

In 1661, the total population of Mumbai was 10,000. It took around 250 years for this to grow to 927994 people in 1901. The next 50 years after 1901 saw rapid growth when the population shot up to 2,994,444 in 1951. Exponential growth occurred in the next 50 years due to which the total population amounted to 11,978,450 in 2001 (Fig. 5.6).

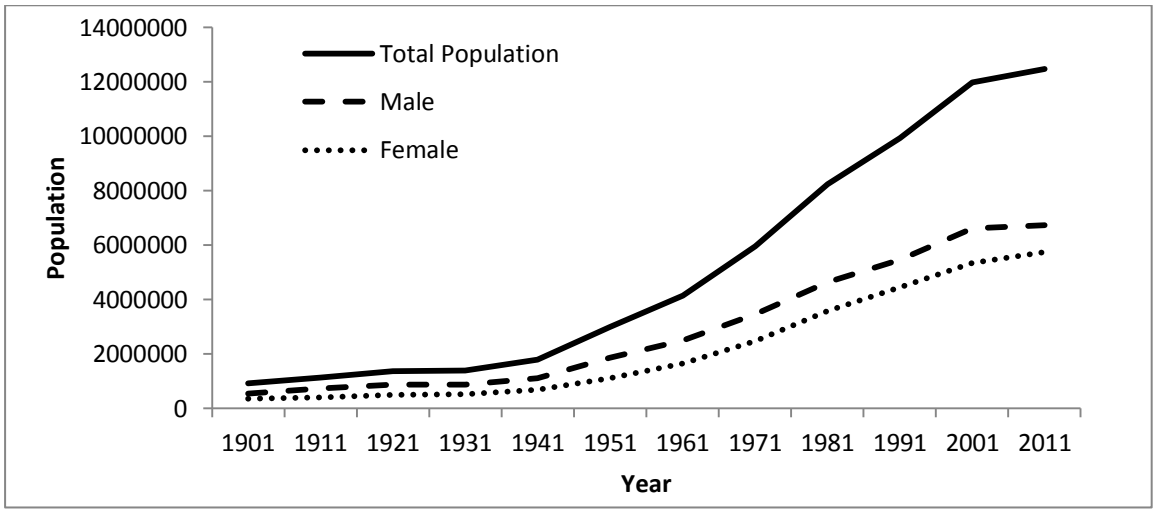


Fig. 5. 6 Population of Mumbai City (1901-2011).
Generated by Author using data from Revised City Development Plan for Mumbai, 2012, p. 42

Over the period of 1901 to 1971, the population in the island city steadily increased and was always more than that of the suburbs. Between 1971 and 2001 however, the population growth in the island city has been negligible while it has grown rapidly in the suburbs with gross density registering a three-fold increase.

1901 to 1971 was the period of the growth of the textile industry and other heavy manufacturing industries, which created a lot of jobs thus attracting people to work in the area and take residence in the *chawl*s constructed as worker's residences. The *chawls* were two- and three-storey buildings with small rooms accessed by long corridors. Each *chawl* building accommodated over 300 families and together, the *chawls* accounted for 75 per cent of the city's housing stock (Swaminathan and Goyal, 2006: 10). However, the demand for housing from the rapidly increasing population of the city soon outstripped the rate at which *chawls* could be constructed and as a result, slums proliferated dramatically after 1950 (Deora and Swaminathan, 2006: 147). From 1950 to 1968, the slums grew to include 18 per cent of the city's population. In the 1970s they further increased to 32 per cent. By 1980 half of the city's population were slum dwellers and today, they make up about 60 per cent of the population; approximately, seven million slum dwellers. The slums however only occupy about 6% of the land area of Mumbai with the residential density in these areas being close to 400,000 persons

per square kilometre. They are scattered over all parts of the city and in land areas of a variety of reservations (Fig. 5.7) with the island city housing 17% of the city's total slum population and 58% and 25% residing in the western and eastern suburbs respectively (Mumbai City Development Plan 2005 – 2025).

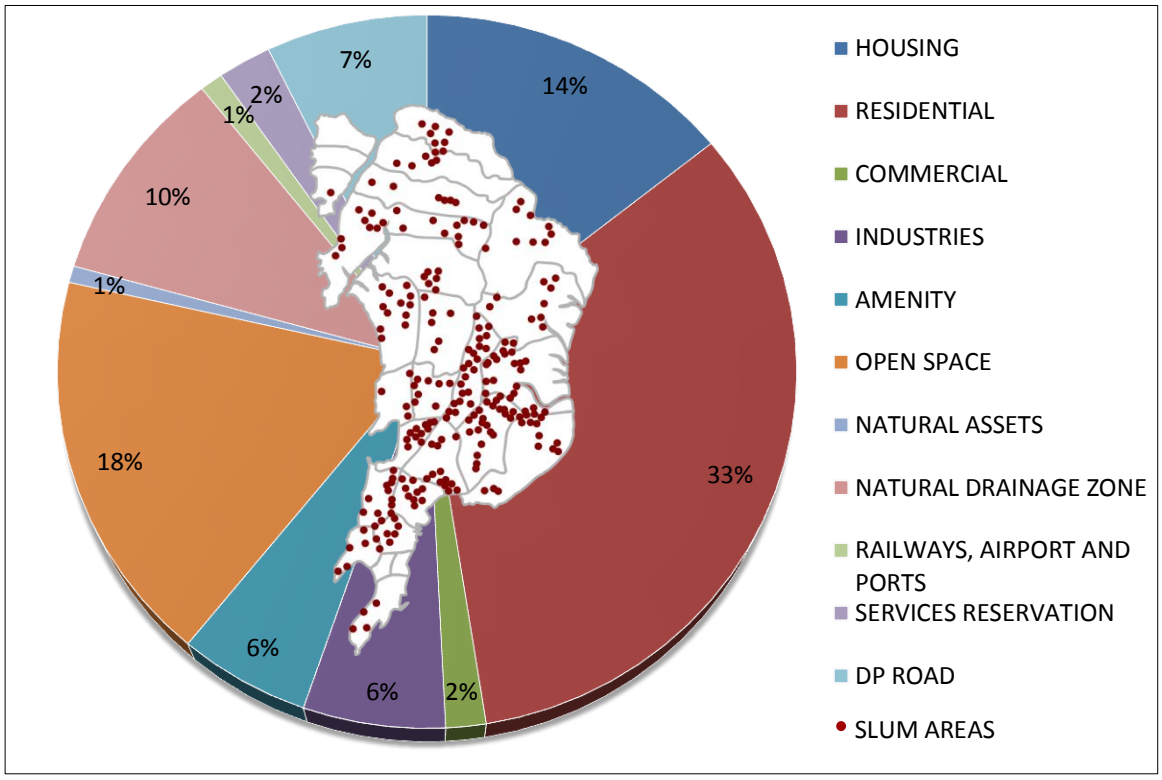


Fig. 5. 7 Spatial distribution of slums in Mumbai and % of land reservations under slum use
Generated by author using data from Mumbai City Mumbai City Development Plan 2005 – 2025, Section 2.12.1.3, Figure 8 and Mumbai Slums Map prepared by P. K. Das & Associates

5.2 Statistical Analysis of Mumbai

5.2.1 DM and DI of Mumbai

DM and DI were framed so as to capture the inequality of the access to income, health, education, infrastructure, governance, jobs, etc. between the wards of Mumbai from previously formulated measures (Table 5.1). Secondary data corresponding to the DM and DI data heads was gathered from a field trip to the city. Since no individual data source had all the heads of data needed, a variety of public, private, and academic organizations as well as practicing individuals were approached. The DI and DM of Mumbai, the data used to compute them, and the sources of these data are shown in Table 5.2 and 5.3.

Table 5. 1 Development Indicators and Density Measures

Development Indicators (DI)	Density Measures (DM)
Income and economic Equity	Physical Density
Health	Intensity
Education	Amenity
Social equity	Autonomy
Environment quality	Frequency
Good Governance	

Table 5. 2 DI with corresponding datasets and data sources for Mumbai

		Dataset	Data Source
DEVELOPMENT INDICATORS (DI)			
1.	Economic Equity	% Regular Employment	Census 2001
		% Unemployment	
2.	Health	Average life expectancy	HDR Mumbai
		Child mortality	
3.	Education	% literate	Census 2001
		Total Enrolment	HDR Mumbai
		Pupil teacher ratio	
		Out of School children	
4.	Social Equity	Number of females per 1000 males	Census 2001
		Literate females per 1000 males	
		Working Females per 1000 males	
		Number of females per 1000 males of slum population	
		Number of female children per 1000 male children of slum population	HDR Mumbai
		Slum Population %	Census 2001
		Resident Dependent %	
5.	Good Governance	Crime Rate(Average Total occurrences/year)	Praja Foundation
		Rank given to local elected representatives	

Table 5. 3 DM with corresponding datasets and data sources for Mumbai

		Dataset	Data Source
DENSITY MEASURES (DM)			
1.	Physical Density	Person/ sq.km	Census 2001
		Households/ sq.km	
		Slum population density of ward/slum pop density of district	HDR Mumbai
		Decadal change in population/sq.km	Census 2001
2.	Intensity	General max FSI of ward	MCGM website
		Residential Intensity=Residential floor space utilized in ward/ residential floor space utilized in entire district	Commercial Geography of a Metropolitan City; Spatial Structure of Retailing in Bombay, Tapati Mukhopadhyay ELU, MCGM
		Retail Intensity=Retail floor space utilized in ward/ retail floor space utilized in entire district	
		Wholesale Intensity=Wholesale floor space utilized in ward/ Wholesale floor space utilized in entire district	
3.	Amenity	No. of open spaces/ sq.km of residential and mixed area	Superintendent of Gardens, MCGM 2009 unpublished data
		% of households, with access to water tap	Annexure of Mumbai HDR 2009 which listed 2001 data
		% of Sewerage coverage of total ward	
		% of households, with access to electricity	

		% Households with telephone	
		ratio of total slum population to number of toilet seats	
4.	Autonomy	Main Workers/ sq.km	Census 2001
		Marginal workers/ sq.km	
		Female workers/total workers	
		female non-working/total non-working	
5.	Frequency	Daily floating density	MCGM website
		Ratio of Daytime density/ Night time density	

The data collected was all at the ward level corresponding to the year 2001. More recent data was not available at the ward-wise level even though a census survey had been conducted in 2011. A unity – based normalization was applied to the data in order to be able to make comparisons between various DM, DI and within the wards. The mean of the group of data for each ward under each of the DI and DM were then calculated to give the values of DIs and DM for each of the wards. The mathematical expression for calculating each DI and DM from the corresponding datasets is shown in equation 5.1.

$$DI\ or\ DM being\ calculated\ for\ Ward\ A = \frac{1}{n}\sum_{i=1}^{n}\frac{A_i - Da_i}{Df_i - Da_i}$$

i = dataset corresponding DI or DM being calculated

A_i = Numerical value of i^{th} data set for Ward A,

Da_i = Most Adverse value of i^{th} dataset among all the wards,

Df_i = Most Favourable value of dataset 'i', among all the wards,

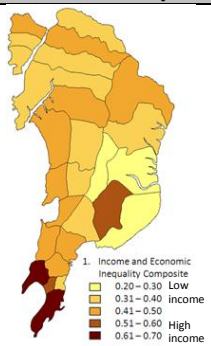
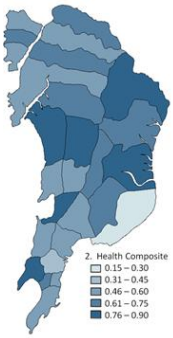
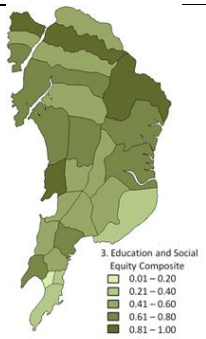
n = Number of datasets in the category of each DI and DM

Equation 5. 1 Equation for calculating DI or DM by taking mean of unity based normalization values of datasets representing each DI or DM

The DI and DM values calculated using equation 5.1 were used to plot thematic maps corresponding to each of the DIs and DMs, using ArcGIS as shown in Table 5.2 and 5.3 respectively. The ward-wise variations of DIs and DMs could therefore be observed which offered a preliminary discussion about the spatial distribution of each DI and DM among the wards of Mumbai. The information about the city acquired from literature study, interviews with experts working in Mumbai in relation to its planning and development as well as knowledge acquired from being a resident of the city was used to draw preliminary conclusions and derive explanations for the spatial distribution shown in the maps in tables 5.4 and 5.5. The data sets used at this stage were different from the final set of data used later in the research.

Since this was still a phase of trial and error, the DIs shown here are different from the final DIs listed previously in Table 5.2, as they are, Economic Equity, Health, Education and Social Equity, Basic Infrastructure, Environment, and Good Governance. The "Basic Infrastructure" DI was later removed since there was overlap of data between this indicator and the "Amenity" density measure. The "Education and Social Equity" DI was split into two separate indicators as the latter was used to measure the gender inequality, and age based inequalities. The "Environment" DI was later removed since the data representation was too sparse and not available for all the wards. All the DMs were retained as shown in Table 5.5 and used in the statistical analysis discussed in the next section.

Table 5. 4 Thematic maps showing ward wise variation in DI

	Development Indicators	Thematic Map	Discussion
1.	Economic Equity		South Mumbai (Ward A, B and C) forms the major economic hub of the city. The areas of ward L, which have many industrial brownfields, ward S and ward M/E which has a large landfill site, are the areas of lowest income.
2.	Health		Low health conditions seen in ward M/E is probably due to open landfill site and many slums along the large mangroves areas. Ward E also shows a low health composite which has many slum settlements in hazardous coastal areas.
3.	Education and Social Equity		Education and social equity between the genders is worst in ward M/E and ward A. The latter may be explained by the extremely high level of gentrification seen in ward A due to its high residential prices due to which it is home to the elite of Mumbai and their poverty stricken service providers residing in squatter settlements.

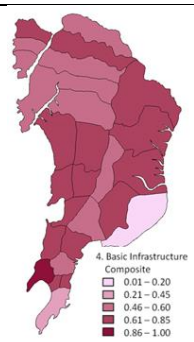
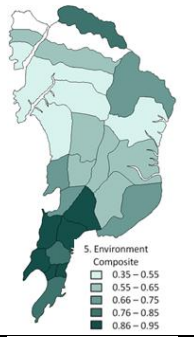
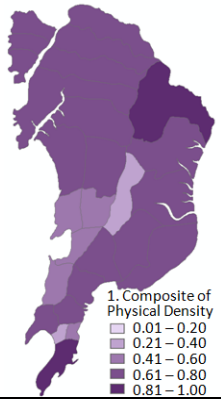
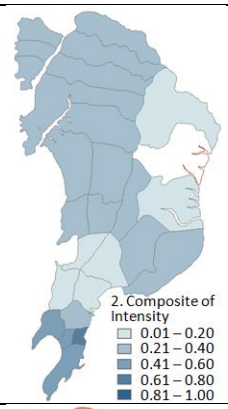
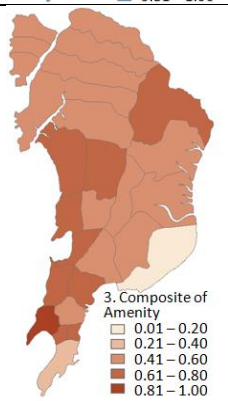
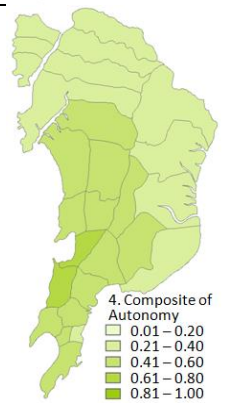
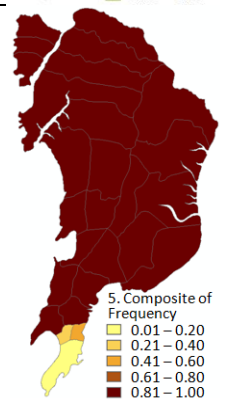
4.	Basic Infrastructure		This is worst in ward M/E due to reasons stated before, and along the linear railway connection that suffers from extremes of density in people travelling each day as well as the continuous rows of slum tenements lining its sides. Open defecation and solid waste disposal is a common sight along this corridor.
5.	Environment		There is a shocking separation of environmental conditions between the inner city wards and the suburbs which are in a much worse state than the southern inner city wards which needs investigation.
6.	Good Governance		South Mumbai and certain northern wards reported much better governance than other suburban wards. The wards of K/W, K/E, H/W and H/E which are the wards with growing populations reported worse governance which is a cause for worry.

Table 5. 5 Thematic maps showing ward wise variation in DM

	Density Measures	**Thematic Map**	**Discussion**
1.	Physical Density		The standardization has been done using highest density as least desirable (light) and lowest density as most desirable (dark). Map 1 therefore shows that the average, residential and household densities have the lowest values in wards A and T. The rest of Mumbai shows a largely even distribution, with high levels of density in the wards surrounding Mahim bay.

2.	Intensity		A very clear pattern is displayed by the composite of Intensity. The wards in the city district and the western wards of the Suburban district have higher intensity. This is in direct correlation with the land prices which is interesting because land price data was not used as a part of Intensity calculation.
3.	Amenity		Amenity is largely lacking in most of the city, with only ward D, T and the western suburbs showing significant availability of amenities.
4.	Autonomy		This shows that the western and southern wards are more autonomous than the eastern wards, which have greater levels of unemployment and inequality of female work participation.
5.	Frequency		Frequency, characterized by floating population and the difference between daytime and night time populations, has the highest values in the southern most wards of A, B and C. The standardization used high density as a deterrent factor which accounts for the low scores of these wards as displayed.

The spatial analyst toolkit in GIS was used to combine the thematic maps (Fig. 5.8).

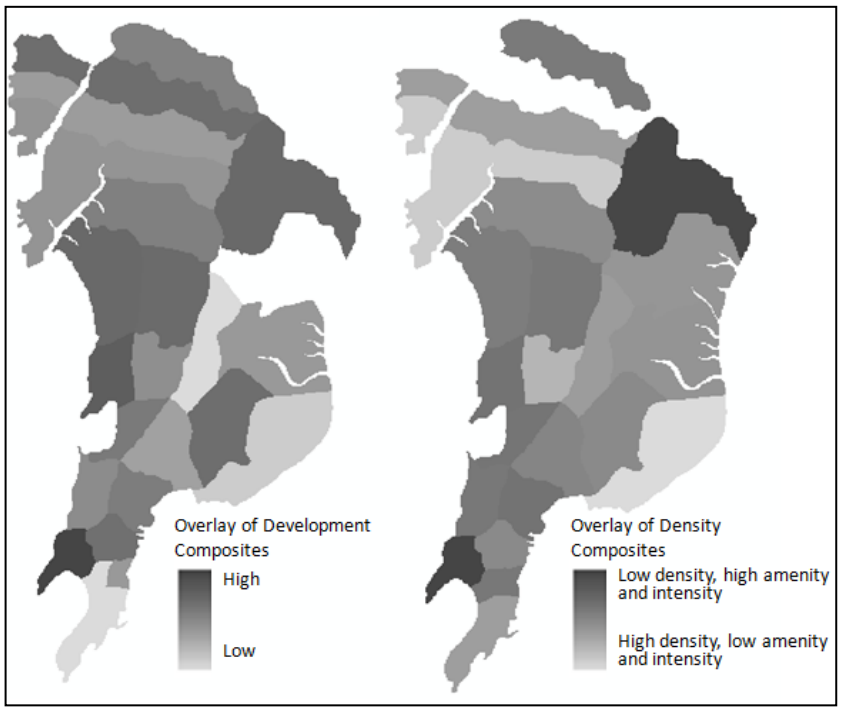


Fig. 5. 8 Composite overlays of DIs and DMs created using ArcGIS Spatial Analyst toolkit

The maps of Economic Equity, Health, Education, Social Equity and Good Governance were combined using the toolkit with a weight of unity assigned to each, to form the overlay map of Development Composites. Similarly, the maps of physical density, intensity, amenity, autonomy and frequency were combined with equal weights, to form the overlay map of Density Composites. It was broadly inferred from the overlay maps that in Mumbai, areas of low density and high amenity and high intensity correspond to high development and better human security. However, the weight of each of the DM in effecting human security was not understood from this analysis due to which further statistical analysis was undertaken.

5.2.2 Exploratory Analysis of Relationships between DM and DI

Scatter Plots of Composite DI and Individual DMs

Scatter graphs were plotted with the measures of density against the composite of all the development indicators for the wards of Mumbai (Fig. 5.9). Thus, overall development composite was plotted on the y-axis, and each of the density measures on the x-axis. No significant patterns could be seen in most of the graphs; however, a strong positive linear relationship could be seen between Amenity density and overall development composite. A slightly weaker positive linear relationship was also observed for autonomy density and intensity density. Physically occupied density and frequency density showed very weak negative relationships.

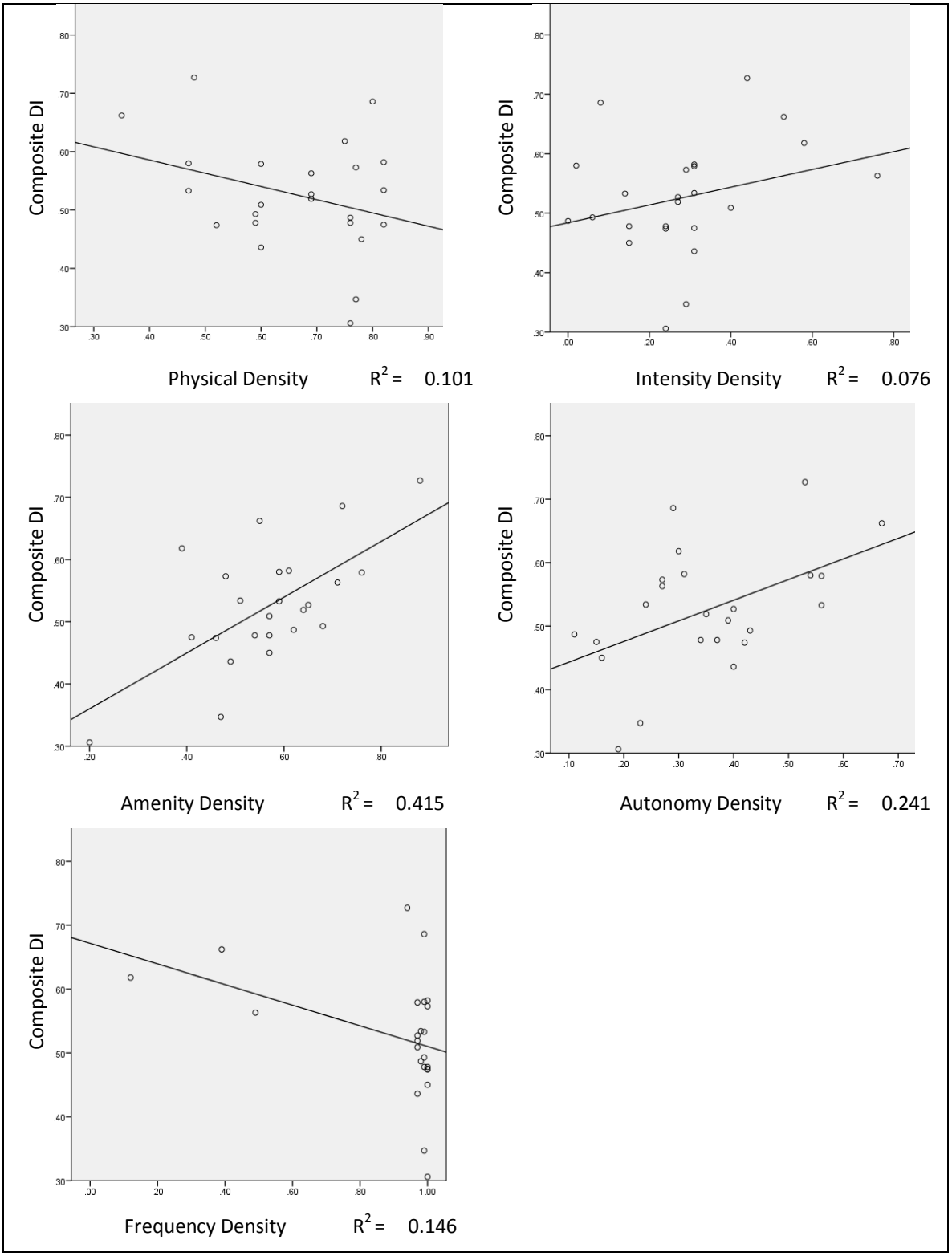


Fig. 5. 9 Scatter Plots of Composite DI with Individual DMs showing coefficient of determination (R^2) in Mumbai

Correlation Analysis between DMs and DIs

A correlation analysis was done using the ward wise data of Mumbai, to find possible correlations between the density measures and development indicators. Table 5.6 shows the Pearson's correlation coefficients and the significance levels.

Table 5. 6 Pearson's Correlation Coefficients significant at the 0.05 and 0.01 levels

	Economic Equity	Health	Education	Social Equity	Good Governance
Physical Density	-0.468	-.272	-.076	-.0005	-.238
Intensity Density	0.66	0.162	-0.187	-0.082	0.139
Amenity Density	0.158	0.639	0.63	0.559	0.096
Autonomy Density	0.544	.415	0.18	.385	.158
Frequency Density	-0.777	-.158	0.064	-0.056	-0.208

Correlation is significant at the 0.05 level (2-tailed).
Correlation is significant at the 0.01 level (2-tailed).

From Table 5.6 we can see that some of the density measures and development indicators are significantly correlated. Physical Density has a strong negative relationship with Economic Equity. Although any interpretations of causation cannot be derived from this correlation analysis alone, an attempt can be made to draw corollaries with the literature studied on the city. Highest Physical Density is found in slum areas of Mumbai, which may also be the areas where people experience the highest levels of inequality, in comparison with other non-slum areas of the ward. The ward with most slum area; ward L in which 21.6% of its total areas is occupied by slums, therefore has the highest physical density and very low economic equity.

It is observed from table 5.6 that Intensity, Amenity, Autonomy and Frequency have more statistically significant and stronger correlation with the development indicators, than the physical density measure. Amenity especially, had a very strong positive relationship with Health, Education, and Social Equity. In a city where about 60 % of the population resides in slums, the inability to access basic amenities such as water, sanitation and electricity, forms the central issue in many people's lives depriving them of health, education and social equity.

Good governance showed no significant correlation with any of the density measures. This is not in accordance with expectations, and the plausible causes of this are discussed later in section 5.2.4.

5.2.3 Multiple Regression Analysis of Mumbai Data

The DM were taken as the independent variables in the regression analysis and the mean of the DI; named the Composite DI, was the dependent variable to see if and how all of the development indicators as a whole, were affected by the combined interaction of the density measures. The model summary and regression coefficients are shown in Table 5.7 and Table 5.8 respectively.

Table 5. 7 Model Summary 1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1.1	0.848[a]	0.719	0.636	0.06019
1.2	0.847[b]	0.718	0.656	0.05853

a. Predictors: (Constant), Frequency, Physical Density, Amenity, Intensity, Autonomy
b. Predictors:(Constant), Frequency, Physical Density, Amenity, Autonomy

Table 5. 8 Regression Coefficients of Model 1.1 and 1.2

Model		Unstandardized Coefficients		Standardized Coefficients	Sig.
		B	Std. Error	Beta	
1.1	(Constant)	.275	.062		.000
	Physical	-.253	.130	-.380	.068
	Intensity	.020	.128	.034	.877
	Amenity	.339	.122	.478	.013
	Autonomy	.346	.169	.480	.056
	Frequency	.160	.096	.372	.113
1.2	(Constant)	.277	.059		.000
	Physical	-.245	.115	-.368	.048
	Amenity	.346	.109	.489	.005
	Autonomy	.333	.144	.462	.033
	Frequency	.172	.056	.400	.006

In the first regression model (model 1.1) the value of the significance for the null hypothesis for "Intensity" was shown to be very high. This led to the conclusion that the measure of Intensity being used for the analysis was not significantly related to the human security of the people, being measured by the development indicators for the wards of Mumbai. The second regression model (model 1.2) was therefore carried out eliminating the intensity measure and this resulted in considerably more conclusive results with an increase in the value for the adjusted R square and a lowering of the significance for the null hypothesis of all the other density measures. The final sig. values are very small (all less that 0.05 = 5%) which means that a good, reliable model can be made using the rest of the DM to accurately predict values for the Composite DI and hence express the relationship between the layers of urban density and human security in the wards of Mumbai.

The relationship between Composite DI and DM in Mumbai in 2001 can hence be expressed as:

$$Composite\ DI = 0.277 + 0.346\ Amenity + 0.333\ Autonomy + 0.172\ Frequency - 0.245\ Physical\ Density$$

Equation 5. 2 Regression Equation of Model 1.2

Equation 5.2 can be stated as; "high infrastructure density, high job density, high public transport capacity and low physically occupied density correspond to higher human security."

Now that an expression had been found to explain the overall relationship between human security and urban density across the wards of Mumbai, multiple regression analyses were carried out taking in turn each of the DI as dependent factors and investigating how all the DM affected it in combination. An expression for each of the DI was found where each depended significantly on one or more of the DM. It was seen that only the good governance indicator showed no significant regression results with any of the DM. This can be due to two reasons. Firstly, it may mean that good governance is in no way related to any of the DM, or, more probably it may mean that the measurement of good governance done in this analysis is incorrect due to data errors. Therefore it was intuited that if for now, the indicator values of good governance were removed from the calculation for Composite DI and this new Composite DI were to be regressed with the DM, then a more reliable relationship between urban density and human security could be found.

Hence the multiple regression analysis was carried out once again, results of which are presented in Tables 5.9 and 5.10. This time the dependent factor being the Composite DI without good governance and the DM being the independent factors; Intensity was once again excluded in the second regression model. The adjusted R square value of this model is 0.688 which is better than that of the previous regression model for which it was 0.656.

Table 5. 9 Model Summary 2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
2.1	.864[a]	.746	.672	.06291
2.2	.863[b]	.745	.688	.06136

a.Predictors:(Constant), Frequency, Physical Density, Amenity, Intensity, Autonomy
b.Predictors:(Constant), Frequency, Physical Density, Amenity, Autonomy

Table 5. 10 Regression Coefficients of Model 2.1 and 2.2

Model		Unstandardized Coefficients		Standardized Coefficients	Sig.
		B	Std. Error	Beta	
2.1	(Constant)	.234	.065		.002
	Physical	-.333	.136	-.455	.025
	Intensity	.047	.134	.073	.730
	Amenity	.385	.128	.494	.008
	Autonomy	.412	.176	.520	.032
	Frequency	.138	.100	.292	.185
2.2	(Constant)	.239	.062		.001
	Physical	-.314	.121	-.429	.018
	Amenity	.403	.114	.517	.002
	Autonomy	.383	.151	.483	.021
	Frequency	.166	.058	.352	.010

Additionally, the sig. values for the second model of this regression was even lower than that of the previous one, hence indicating this to be a better model. A new expression was found for the relationship between Composite DI (without good governance), and the DM of Physical density, Amenity, Autonomy and Frequency:

$$\textit{Composite DI without Governance} = 0.239 + 0.403\ \textit{Amenity} + 0.383\ \textit{Autonomy} + 0.166\ \textit{Frequency} - 0.314\ \textit{Physical Density}$$

Equation 5. 3 Regression Equation of Model 2.2

The values predicted (for Composite DI without good governance) by equation 5.3 were plotted against the actual values to visualize the degree of error which are all less than 5% as shown in Fig. 5.10.

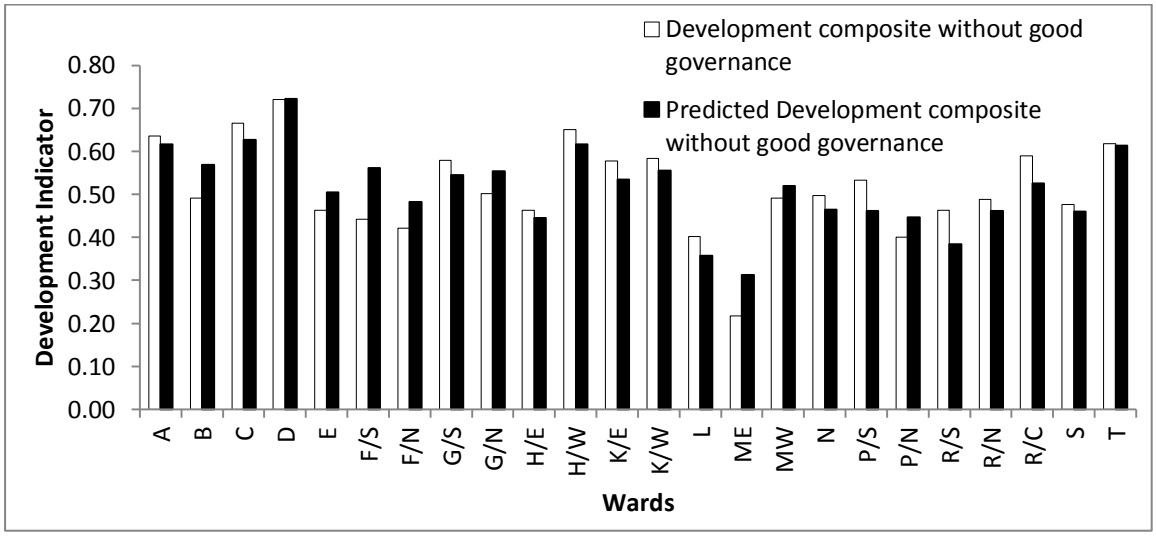


Fig. 5. 10 Actual and Predicted values of Composite DI in Mumbai

Observations from Regression analysis

From Equation 5.3 it can be said that in 2001, Amenity had the greatest effect on human security across all the wards of Mumbai followed by Autonomy (job density) and Frequency (migration or transport density). Additionally, physical crowding by people occupying urban area had a negative effect on human security. These observations are concurrent with the general urbanization trends seen in large cities of Asia in which the surge of economic growth often outpaces the development of supporting basic infrastructure, amenities and housing. A large part of the population which migrates to cities for better employment ends up living in slums and squatter settlements. Although their earnings may be increased, their quality of life often suffers in the absence of any legal entitlement to shelter, clean water, electricity and proper sanitation, hence putting amenity at the centre of planning for increased security.

Autonomy derives its importance from the fact that a large proportion of the working population of Mumbai are engaged in informal jobs which do not ensure any security in case of adversity. These workers and their dependents are extremely vulnerable as they have very little savings and no financial reserve to depend on in case of a natural disaster, medical emergency, or if the earning member becomes incapable of working. Children are forced to work from a very young age to become a secondary source of income to counter insecurity, but this compromises their education which leads them into poverty traps and further reduces their security. The creation and formalization of informal jobs therefore becomes an important factor for consideration in planning for increased security.

The increase in urban density also exerts extreme pressure on the existing transportation networks of the city. This effects travel time and pollution which in turn diminishes the overall efficiency of the economic processes fuelling the growth of the city. A high migration density suggests an increased primacy of the urban area over its surrounding hinterland. If the transportation linkages have the capacity to support this migration, then a large number of people can benefit from the wealth generated in the urban area. Additionally, many layers of alternate transportation linkages need to be created for the use of people travelling within the city and those travelling from outside. This planning should also be such that there is always a support for the primary linkages in case one or more are destroyed by natural or manmade disasters.

Although the factor of Intensity was eliminated by the regression analysis, the FSI of various land uses ought to have an impact on the security of individuals residing in the urban area. Perhaps, there was an error in the way the data was used in the analysis, because the number of people using each square meter of floor space of each of the land uses could not be calculated. If such a calculation were possible, it could provide insights into how security is affected by Intensity. This would give a measure of actual crowding in various activities which, if extremely high, may have a wide range of negative effects as studied in proxemics and environmental psychology. However, in the absence of the availability of such data also, the analysis done so far can be understood as the following:

"Less crowding for amenities, jobs, transport and land gives rise to
better human security."

5.2.4 Cluster Analysis using DI

A cluster analysis using several clustering methods (two step cluster analysis, hierarchical 4 and 5 cluster analysis, k-means cluster analysis), was done to find the ward clusters with different levels of DI as shown in Fig. 5.11.

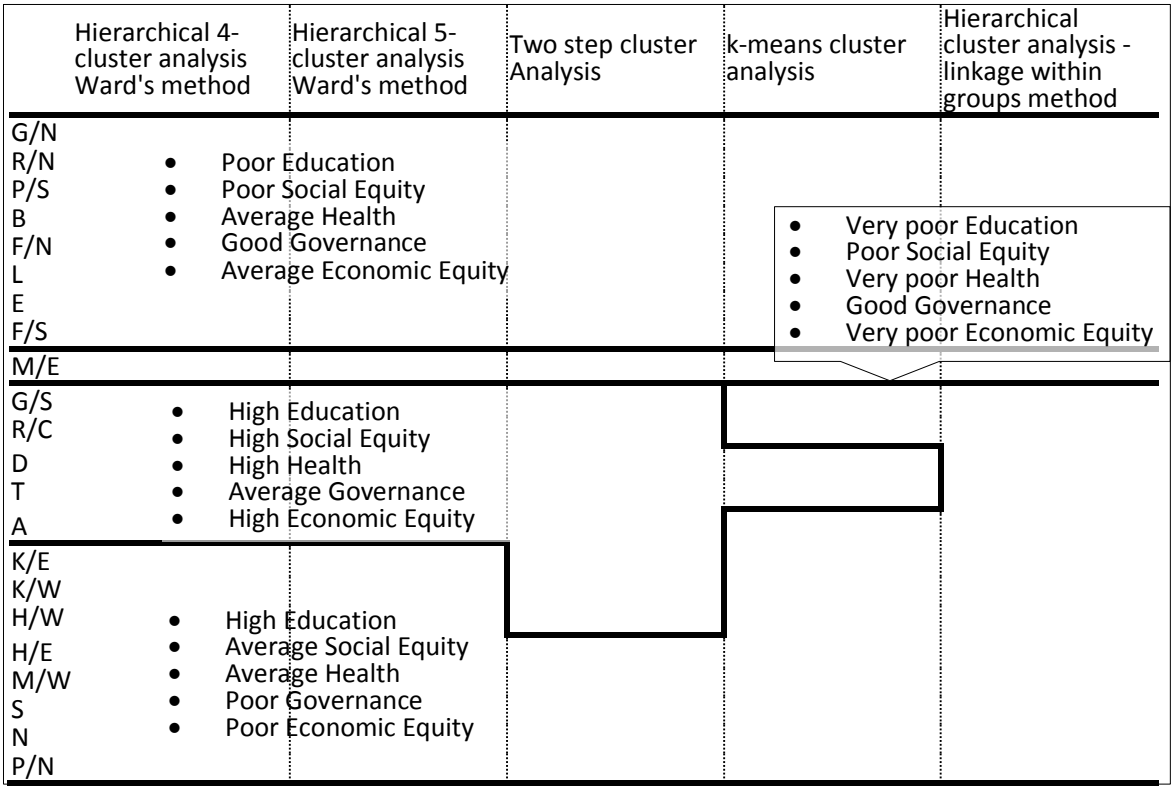


Fig. 5. 11 Initial Cluster Analysis of Mumbai

From this analysis it was understood that Education, Social Equity and Health played a very important role in deciding the human security of an area. However, the measure of good governance showed a negative correlation. Possible reasons for this may have been due to:

1. The governance was measured based on two datasets; crime rate and "MLA report card" measured based on a survey to asses MLA's accessibility, transparency, non-corrupt, perceived performance, criminal records, etc. which could have reported responses which may have been influenced by political power or incentives
2. People frame opinions based on their own lives. The ward of poorer human security may have seen some increase in employment or infrastructure, which, although may not be sufficient for the overall development of the ward, may have given poverty stricken residents the impression that their conditions had improved.
3. Some local MLAs use areas of lowest human security as vote banks by giving short term benefits to keep the residents happy, but not give them long term benefits so they remain in need of the local authority's charity. Although this cannot be proved by data, it is a political reality. People living in lowest human security may have migrated from rural areas of worse conditions and so, may be satisfied with their current conditions.

Since the education level is very low in areas of low human security, the judgment of quality of governance may not be accurate.

The cluster analysis was therefore repeated, rejecting Good Governance from the list of clustering factors. The final clustering was done using the Ward's minimum variance method of hierarchical cluster analysis using squared Euclidean distance as the interval measure and composite DI without Good Governance as the clustering criteria. Ward's minimum variance criterion minimizes the total within-cluster variance. The pairs of clusters with minimum inter-cluster distance are merged at each step. The results of the cluster analysis are shown in Fig. 5.12.

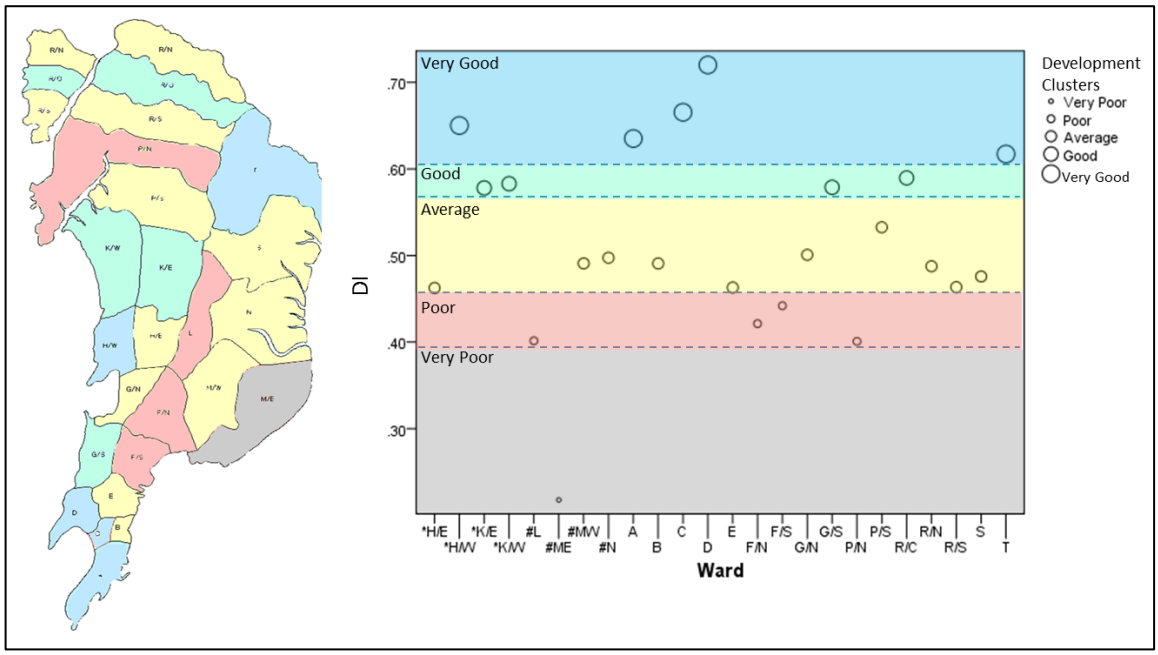


Fig. 5. 12 Cluster analysis of DI of Mumbai using Ward's method of minimum variance

From this cluster analysis, 5 different levels of human security have emerged among the wards of Mumbai. The best DI wards are in the south where the old CBD is located and in the west where the new business zone has been developed. Areas of good human security surround these wards. The railway line has long stretches of slum which is probably the reason for the low DI wards along the railway line, in the heart of the city. The worst ward in terms of DI is ward M/E. This ward has a large area dedicated to open animal slaughter, a very large and unsanitary open landfill and also power plants and other heavy industries.

A survey was conducted to photograph these clusters for a better understanding. A few sample photographs are shown marked on the map of Mumbai, in Fig. 5.13. The observations recorded on site are presented in table 5.11.

Table 5. 11 Observations of clusters from field survey

Cluster	Location	Observations
Very Good Human Security	Sassoon Dock, Colaba	• High rise, high income residential and mixed use area with high rise commercial and financial hub nearby. • The port area attracts huge numbers of fish vendors in the morning who come to buy fish from the fishermen, at Sassoon Dock. These are then transported to all the markets in Mumbai, usually carried on baskets in the public trains.
	Horniman Circle, Fort	• Old colonial buildings mostly banks and institutions. Medium rise buildings. Good public plazas and street character.
Good Human Security	Bandra Kurla Complex	• New financial hub. High rise well maintained buildings and landscaped. Planned parking areas. Probably deserted at night-time since all the buildings are offices.
	Bandra East	• Slum areas along the railway tracks. Also, high density slum tenements rising to 3-4 floors line the streets with businesses spilling out on the streets. • Very bad street congestion worsened by on street parking. • Unhygienic, highly polluted and high risk living along railway tracks.
	Lokhandwala, Andheri West	• High rise, high income residential and mixed use area. • Public parks and recreation areas present. • Some slum settlements also present which largely house the service providers of the affluent sector.
Average Human Security	Dadar	• Railway colonies located near the important rail junction. • Many old mill buildings and dilapidated industries in the area. • Many old government housing buildings which are in crumbling condition, yet inhabited.
	Mahim	• Temples have been used to claim and encroach upon public areas. • Stark divide of affluent and poor areas. • Many slum settlements and challis which were once and some still are quarters for government and police employees. • Mixed land use especially near station area.
Poor Human Security	Saki Naka	• High number of slum tenements stretching for a long distance, on hill slopes, along roads and the metro line under construction. • There is a large pipeline for water supply passing through this area. This has slums all along it in extremely unhygienic conditions. • Very bad condition of buildings and roads. • Traffic congestion is common.
	Sion	• Middle to low income mixed use, vibrant area with lots of formal and informal commercial establishments. • Dharavi is located nearby, which is one of Mumbai's largest slums.
Very Poor Human Security	Govandi	• Slaughter houses which supply meat to all parts of Mumbai are present here very near the train station. There are only sheds for the slaughtering activity and so much of the process is carried out in the open. This is very unhygienic. • There are slums near the railway tracks all along. • There are old government housing buildings and slum rehabilitation buildings which are in very bad condition yet house a large number of people. • A very large open garbage dumping site is located just beyond the slaughter site. There are many slum settlements of inhumane conditions within the premises of the dumping site.

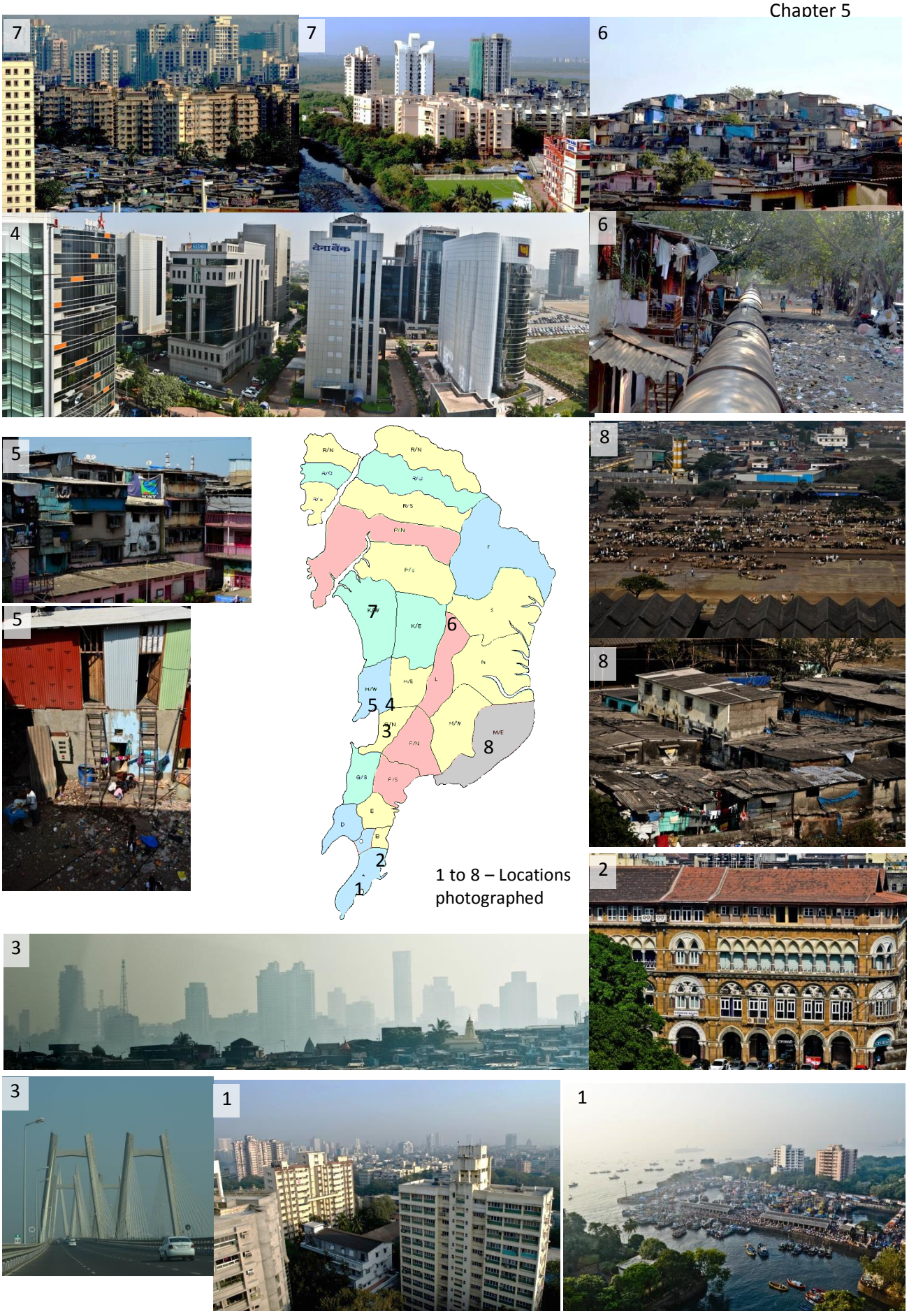


Fig. 5. 13 Photographs showing characteristics of various DI clusters

Observations from Cluster Analysis and visit of study area

The railway lines form the central nervous system of the linear city and are laid down along the low lying corridor. Due to the large number of people that pass through it every day, a lot of commercial activity gravitates around the railway system. Slum dwellers naturally settle near these commercial hubs aided by the presence of vacant land along the railway where formal development is prohibited. The presence of such squatter settlements raises the physical density of the area. Also, although the autonomy is good, the amenity is very poor, further intensified by being vulnerable to flooding as they are at such a low elevation. The railway corridor of Mumbai therefore exhibits a poor level of human security.

The new business node of Mumbai is located in the Bandra-Kurla Complex. This area is geographically more centred in the city than the previous node. It is also strategically located close to the Airport, major rail junctions, and has recently been given a direct connection to south Mumbai via a bridge called the "Bandra-Worli Sea link". This area is attracting huge investments and multinational companies and so generating a large number of jobs. At the same time, many slum settlements exist in the vicinity of this area, which house the informal sector that serves the formal economy. Although this area has a high level of autonomy, the level of amenity density is low which causes it to have good or average levels of human security.

The ward M/E located in the east shows to have very poor level of human security. Slaughter houses which supply meat to all parts of Mumbai are present here very near the train station. There are only sheds for the slaughtering activity and so much of the process is carried out in the open. This is very unhygienic. A very large open garbage dumping site is located just beyond the slaughter site. There are many slum settlements of inhumane conditions within the premises of the dumping site. The level of amenities in this area is extremely poor as is autonomy and frequency. This is the ward identified to have the worst human security level, by the cluster analysis.

The cluster analysis had also identified the differences in lowest of human security because, although there may be slums in cluster 1 as well as in cluster 4, they varied greatly in character. The slum dwellers in cluster 4 live in unimaginably unsanitary conditions in vulnerable hutments, and are in frequent contact with mass open animal slaughter, human refuse, and large city serving landfill site. They have no stable employment and are endangered by the heavy monsoon every year. The slum of the better clusters are structurally more stable, have a large number of industries being run and have access to electricity (noted by the presence of satellite dishes) and water.

Having identified the areas of different levels of DI in Mumbai, it is important to study the DM of each of these areas and see if the negative relationship between crowding and human security is statistically reflected in these clusters. A graph was plotted to see the DM in each of the four clusters, shown in Fig. 5.14.

It can be seen from Fig. 5.14 that the negative correlation between crowding and human security are followed in most cases; Amenity decreases from cluster 1 to 4, Autonomy and Frequency decrease with the exception of cluster 2, and physical density increases from cluster 1 to 3 although it is very low in 4. The exceptions seen are probably due to the clustering being affected by the "good governance" indicator. Hence, it can be concluded that high crowding for infrastructure, jobs, transport and physical space, directly corresponds to a lowering of education, social equity, health, and economic equity. Additionally, it can be extrapolated from the cluster analysis that to improve the human security of an area, improving education levels would have the largest effect, followed by social equity and healthcare.

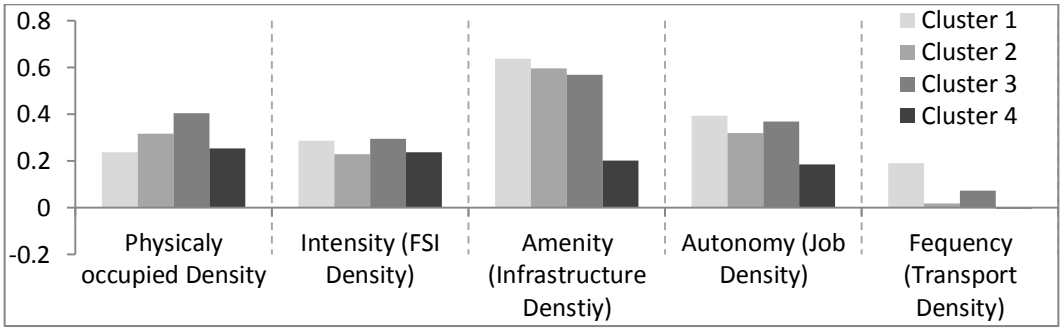


Fig. 5. 14 DM of each cluster

5.2.5 Inter-cluster variations of DI datasets

The clustering was done using composite DI (without Good Governance) so naturally, they represent various levels of DI with the average DI of each cluster being 0.66, 0.58, 0.49, 0.42 and 0.22 (very good human security to very poor human security). However, it is also important to know the individual datasets which define the DI and understand how each varies according to the clusters. The mean values of data sets that make up DI such as percentage of ward population living in slums, average life expectancy, percentage of unemployed people, etc., were found for wards in each cluster. These mean values were plotted for each corresponding cluster and the coefficient of determination R^2 of the linear relationship between each dataset and the clusters was found in order to see to what degree the dataset weighed in with the clustering. The datasets which had R^2 greater than 0.5 with cluster wise linear decrease of DI from the best to worst cluster, have been shown in Fig. 5.15.

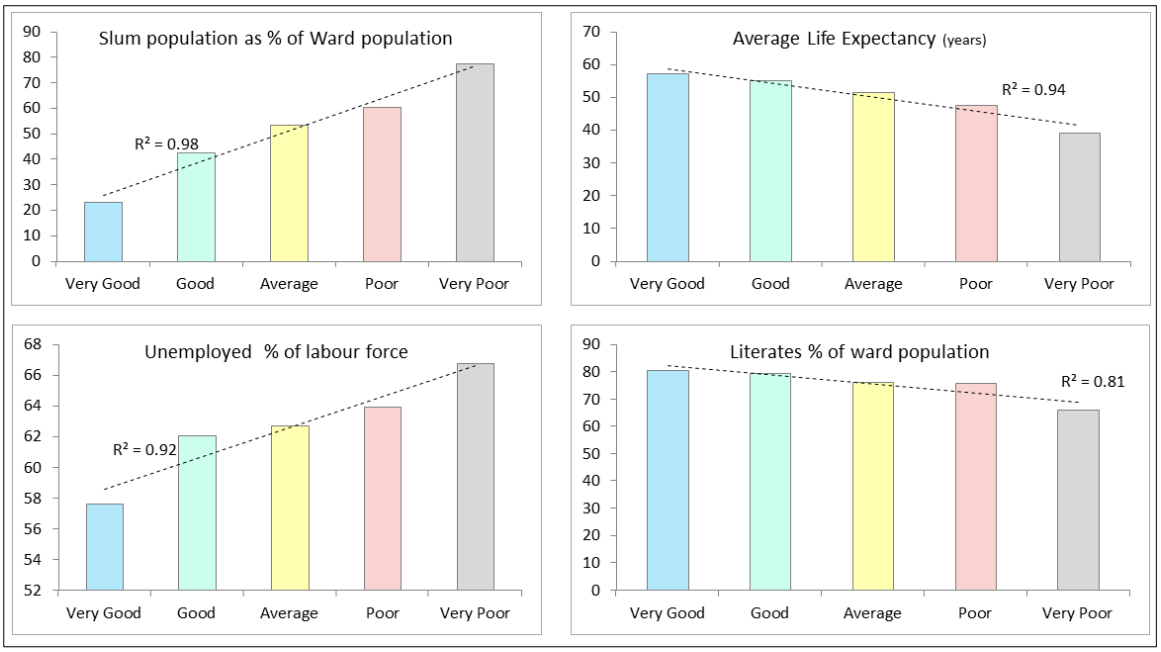


Fig. 5. 15 Cluster wise mean variation in significant DI datasets (R^2>0.5) for Mumbai

It therefore follows that **areas of high slum population, high unemployment, low average life expectancy, and low literacy** as compared to the rest of Mumbai, are the areas of **low human security**. It therefore also follows that these are the areas which need prioritized planning interventions to improve the human security of the inhabitants.

5.2.6 Variations in DM datasets corresponding to DI clusters

A relationship between DI and DM has been found through regression analysis as shown previously in this report. Hence, it was interesting to understand the variation of the constituent data sets of DMs across the clusters which are created on the basis of DI. As before, the mean values of each data set was calculated for wards in each of the clusters. It was then seen how the mean values varied linearly across the wards. The datasets with R^2 greater than 0.5 have been shown in Fig. 5.16.

It is seen that the datasets corresponding to Amenity; Sewerage and Water supply coverage, and the data set corresponding to Autonomy; Local Employment Ratio, have a strong positive linear relationship with DI. Floating density and gross density measures of population and household also show a linear relationship using cluster means of these datasets, however, looking at the minimum and the maximum values, it can be seen that the R^2 is misleading. Even though gross physical density is greatest in the wards of Mumbai with highest DI, the maximum and minimum values of this dataset do not follow the linearly diminishing trend across the other clusters. Floating density too is only positive in the highest DI cluster and the average DI cluster so an absolute linear relationship across all the clusters cannot be concluded.

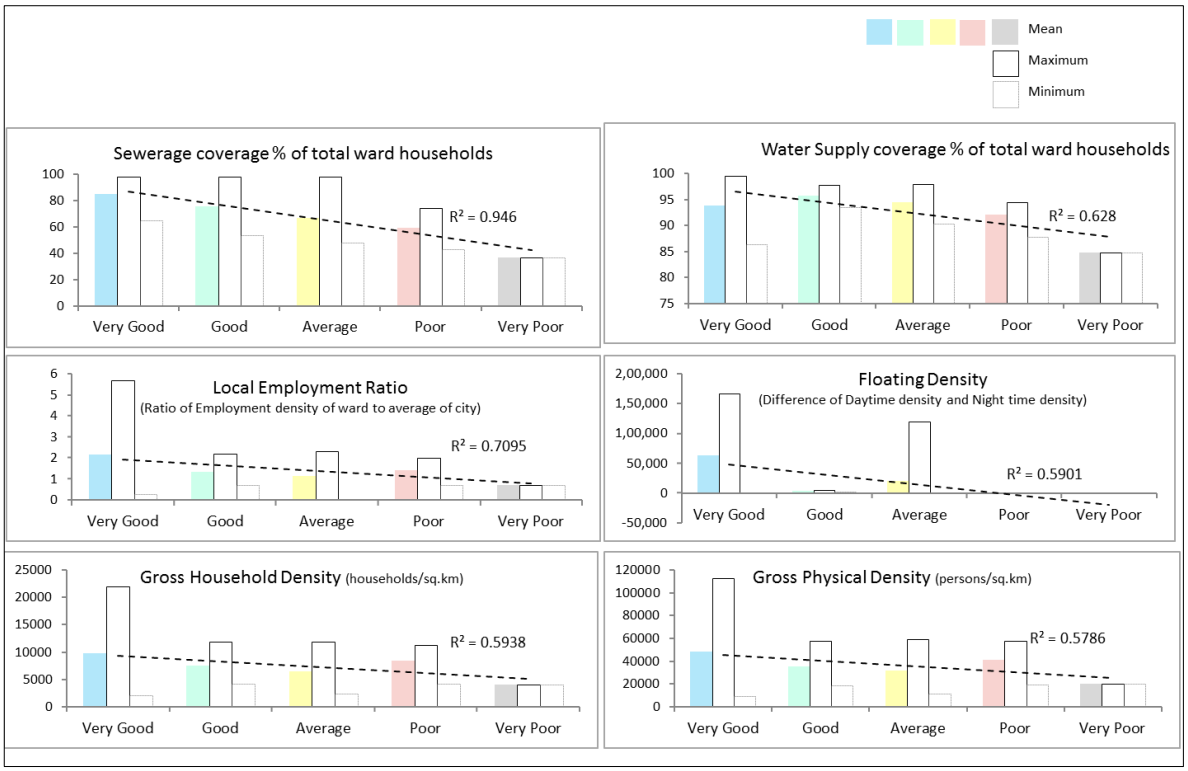


Fig. 5. 16 Cluster wise mean variation in significant DM datasets (R^2>0.5) for Mumbai

5.3 Discussion

The results of the statistical analysis prove that there does indeed exist a relationship between DM and DI in the wards of Mumbai, for data from 2001. The regression equation for this relationship, stated in Equation 5.3 is;

$$DI = 0.239 + 0.403\ Amenity + 0.383\ Autonomy + 0.166\ Frequency - 0.314\ Physical\ Density$$

Additionally, the cluster analysis showed that ward M/E had the worst level of human security, followed by wards L, F/S, F/N and P/N. Low human security was characterized by high numbers of ward population residing in slums, high rate of illiteracy, low number of women as compared to men, and high unemployment rates. A general east-west divide is seen, with the western part of wards being better developed and the eastern parts housing slums and the informal sector. Therefore, in the wards which fall under the cluster of average human security, very poor human security has been identified in certain patches within these wards. However, since neighbourhood level data is not available, this aberration from the actual is unavoidable.

Furthermore, the density characteristics that correspond to such human security issues are low sewerage and water supply amenity and low autonomy requiring people to travel out of the ward for employment. It can be concluded that in Mumbai, in 2001, Crowding of infrastructure, jobs, transport and physical space had a negative effect on Human Security. A

study of crowding theories reveals that if some amount of social exclusion is already present, then crowding will further aggravate these issues. Effectively, this means that urban density can be optimized for increased Human Security by increasing social choices and allowing greater control for the residents, along with increasing the physical infrastructure capacity, job density and transport capacity. A socio – physical approach must therefore be adopted to reduce the social-stresses.

5.3.1 Slum Redevelopment and Rehabilitation Policies

The government of Maharashtra has made several attempts over the years to reduce the number of slums in the city, hence reclaiming the land currently blocked by these settlements, by providing policy frameworks to generate affordable housing for the urban poor.

The Maharashtra Slum Areas (Improvement, Clearance and Redevelopment) Act, 1971 allows the declaration and notification of an area to be a “slum”, so as to earmark it for improvement. There have been various development schemes through which such improvements are attempted.

The Slum Redevelopment Scheme (SRD) introduced in 1991 brought the private sector into slum redevelopment activities with a promise of providing affordable incremental space/tenements to slum residents who had settled in Mumbai prior to 1985. The eligible families were assured 180 sq. ft. per family, on a thirty year lease with a non-transferable bond for 10 years. One third of the subsidized cost was to be paid upfront by the slum dwellers and the remaining in loans. The subsidization was made possible by granting the private sector an increased FSI of 2.5 for developing slum areas. The scheme also required the consensus of 70% of the residents of a slum for it to be eligible for redevelopment. This met with several issues, majorly due to the slum dwellers’ distrust of the private sector. Only 86 of the 178 schemes submitted were approved as the lease hold right on land could be acquired only after project implementation before which the slum dwellers were expected to pay one-third of the total cost.

The Slum Rehabilitation Scheme (SRS) was a perceived improvement over the Slum Redevelopment Scheme as it made all slum dwellers on the electoral roll of 1995 including pavement dwellers eligible for rehabilitation. Furthermore, it increased the area of the tenement to be provided, to 225 sq. ft. which were also to be provided free of cost. For the private sector, it allowed an increased 5% commercial component and Transfer of Development Rights (TDR) of any surplus floor area could be constructed in another site to the north of the original site.

5.3.2 Dharavi Redevelopment Plan (DRP)

The actual effectiveness of the Slum Rehabilitation Scheme and the many outcomes of its implementation can be understood by analysing the changes in DI and DM that its implementation will bring to an area.

Taking an example of a slum where it is proposed to be implemented such as the Dharavi slums. According to the National Slum Dwellers Federation (NSDF) Survey carried out in 1985, the population of Dharavi was 530,225 persons, with a density of 302,985 persons/sq. km. Unofficial estimates suggest the current population is about **1,000,000 persons** with a density of **350,000 persons/sq. km**. It is famously known as one of the largest and densest slums in the world. It is also home to a large industrial base, with an annual economic output estimated to be **$6000 million to more than $1 billion** (Yardley, 2011). This industrial activity is completely informal and thrives in spite of any support from the government and acts as a major support for the formal economy. It is a hub of recycling and has a host of manufacturing industries such as furniture making, clothes making, pottery, leather work, luggage making, automobile repair, kitchen appliance making, jewellery making and many others (Fig. 5.17). All of these activities are carried out in rickety shanties piled up to four stories high, with extreme lack of electricity, water, and other basic services. The vibrancy and creativity witnessed in this slum is a result of the perseverance of its inhabitants to survive in the worst of conditions due to which Dharavi is a major contributor to the economic vitality of Mumbai.

Fig. 5. 17 Informal industries operating within Dharavi

A critical overview of the government's Dharavi Redevelopment Project (DRP) is presented below:

1. Dharavi was divided into 5 sectors and bids were invited from private developers to provide free housing and infrastructure to rehabilitate the slum dwellers within the same area.

2. The area where Dharavi is situated has often been described to be a gold mine in terms of latent value of land, due to its central location in the city (Fig. 5.18), well connected to important nodes by road and rail.
3. The Government's plan, prepared using the Slum Rehabilitation Scheme, proposes the resettlement of the entire slum population in 43% of the land area of Dharavi. Since Dharavi is at an extremely lucrative location, the government plans to sell the remaining 57% to gain revenue and also finance the resettlement project.
4. Given the high real estate value, this spells very high profits for private developers.

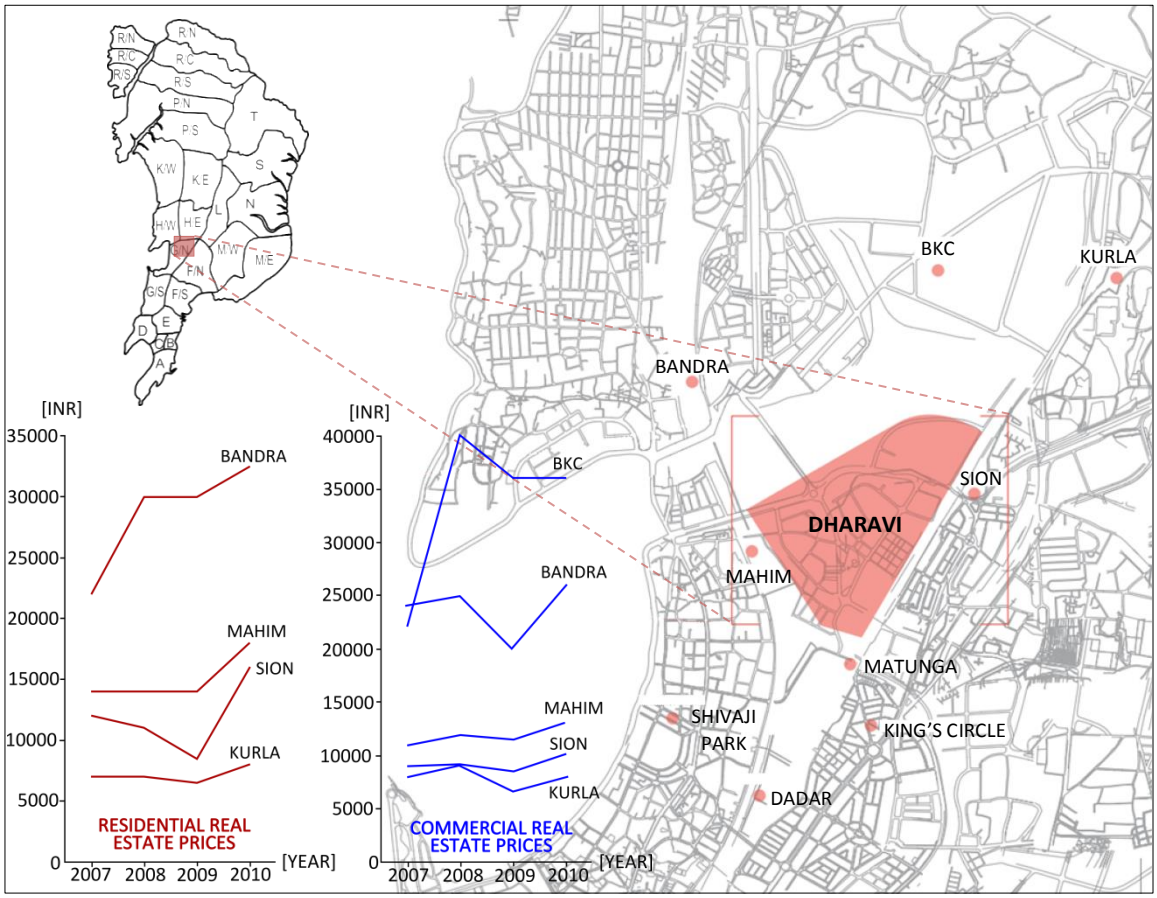


Fig. 5. 18 Location and real estate value of Dharavi
Image adapted from "Re-interpreting, Re-imagining, Re-developing Dharavi", SPARC, KRVIA, pp. 11-12

5. The eligible slum dwellers (based on duration of stay and excluding those residing on mezzanine floors) would be provided a free apartment per family in the rehabilitation buildings.
6. The resettlement is proposed to be done in high rise buildings, providing apartments of 25sq.m for each family of 5. According to the plans of the rehabilitation buildings, these high rise structures will have 21 apartments on each floor.

7. The residents will not be able to set up their industries in these tenements thus causing wide spread unemployment, loss of revenue and destruction of a vibrant community.
8. Infrastructure up gradation has been promised, but a development plan detailing these promises has not been produced. Furthermore, most SRA buildings completed in other parts of Mumbai suffer from poor infrastructure facilities which give rise to vertical slums. Transit camps also need to properly planned as these have worse conditions than existing slums.
9. The 53 % of the land that will be sold will be developed as business centres, commercial areas, and high income luxury residential buildings. An FSI of 4 will be allowed for this sale component. This will ensure that the population of the area will at least be doubled and the density of the slum resettlements will be three times the current value.
10. In the absence of sufficient open areas and green spaces, such a high density will result in extremely high built intensity, very unhealthy living conditions and cause a considerable lowering of Human Security, which is exactly the opposite of what slum re-development should do. The loss of industrial workshop spaces coupled with unhealthy living conditions may encourage the rehabilitated slum dwellers to leave their apartments and establish new squatter settlements at other areas of the city.
11. The increase in Physical Density, insufficient increase in amenity and drastic lowering of autonomy will intensify crowding conditions, have detrimental effects on this area and severely harm the capabilities of the people.
12. Furthermore, the Dharavi Redevelopment Plan has been created by a top-down approach with very ineffective participation from the local residents. There has been wide-spread resistance from the locals captured by the media, who have demanded a low-rise, high-density approach rather than a high-rise, high density approach. They have also appealed to be allowed to run their businesses and retain their commercial establishments along the main streets of Dharavi.
13. The exclusion of the opinions of the local population is an additional act of social exclusion. Although the slum residents do not have legal tenure of the land, they are active contributors to the city. They are extremely resilient due to which they have been able to carve out homes and livelihoods. Exclusion of financially weaker sections will increase the gap in the DI of the best and worst clusters.
14. The regression equation 5.3 gives a good idea of this; if nothing else is changed except physical density, then a 3 times rise in physical density will cause DI to be reduced by (0.314x3) = 0.942. Of course other things such as amenity will be changed, which will help to raise it, but the quality and extent of amenity will determine how much it affects DI. Also, the autonomy

will be seriously affected. Although the statistical analysis in this chapter has been done using data of formal jobs, a large part of the population is dependent on informal jobs and this sector must be strengthened for improving autonomy which in turn will increase DI.

5.4 Conclusion

This chapter has used Mumbai as the study area to apply the measures and methodology built in the previous chapters, to test the hypothesis of understanding the relationship that exists between urban density and human security. The achievements of this chapter are listed below:

1. A list of objectives had been laid down in chapter 1, of which the first two had been achieved in chapters 2 and 3, through the formulation of DM and DI respectively. The **third objective** was to successfully apply the DM and DI to adapt them according to data availability and the historical, economic, political and social context of the city. This has been **achieved in this chapter**. Secondary data collected from a wide range of sources have been used to compute the DM and DI which reflect the urban density conditions and human security conditions of the city.
2. The **fourth objective** laid down in Section 1.4 of Chapter 1 intended to derive substantial relationships from ward wise comparisons between levels of Human Security and measures of Urban Density and identify the elements of crowding in each city. This has been **successfully achieved in Mumbai**. The statistical analysis has revealed that **high slum population, high unemployment, low average life expectancy, and low literacy** are the characteristic features of low human security in Mumbai. The crowding for physical occupation of residential area, access to main sector jobs and access to basic amenities, all features found typically within slum settlements, are the DM features corresponding to low human security.
3. The **fifth objective** was to identify ward clusters of differential human security levels. This has been **achieved for Mumbai** in this chapter. It has been demonstrated that DI can be used to identify the areas of a range of human security. Thus, areas of “very poor” human security can be found which need to be prioritized.
4. The identification of such zones has been successfully achieved using very limited and easily available public data, which further emphasizes the **merit of this technique for planning urban areas in developing countries where data availability is very difficult**.
5. Urban planning practices done using DI clusters as a foundation, allows for **comprehensive planning**. Traditionally, plan formulation is often done on a sectoral basis. However, by calculating DI many aspects of economic, social and environmental issues are taken

together. Also, by calculating DI based on inter ward inequalities, the differences in their levels help to identify different stakeholders at varying levels of DI within the city.

5.5 Way Forward

5.5.1 Need for micro level analysis

As stated earlier, the cluster analysis has successfully identified ward clusters of low DI and these results allow for some wards to form the primary focus of developmental efforts. However, since slum areas are the main causes for concern in Mumbai, development strategies only focussed in certain vulnerable wards, will cause the slums in the rest of the wards to be neglected. A micro level analysis to identify standard urban typologies representative of inadequate DM levels is therefore necessary. In order to easily identify vulnerable neighbourhoods in each ward in the absence of detailed secondary data at the neighbourhood level to analyse the DM levels of each part of the city, a set of micro indicators is required. Micro level analysis of sample areas representative of different DM levels is required to see if standard urban typologies exist in each area. The identification of such standard urban typologies can then help to easily identify poor DM areas which stand a greater probability of having low DI, in other wards by matching the respective characteristics found in the sample wards.

5.5.2 Need for forecasting and modelling of Density Measures

The analysis done so far has used data of Mumbai obtained from the 2001 census. The relationships obtained, between DI and DM, are therefore a reflection of Mumbai at that time. These relationships will change as the city evolves. The change in DI has various possibilities; the socio-economic gap may increase, remain constant, or in the ideal situation get reduced over time. The DM variation with respect to DI will therefore also change. A forecasting of DM based on urban density models will help to understand the multifarious possibilities and guide development activity.

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Chapter 6:

STUDY AREA: AHMEDABAD

"Ahmedabad holds the distinction of having remained prosperous and prominent through the centuries….myth intersects with history, domination with dissent, and tradition is transformed by innovation. Ahmedabad has experienced all these aspects and reflects them in its mosques, mills and malls and the millions who live here."

- *Yagnik and Sheth*

6.1 Introduction to Ahmedabad and its Urban History

Ahmedabad is located in Gujarat which is on the western coast of India (Fig. 6.1) geographically situated between 22˚55'N and 23˚08'N latitude, and 72˚30' and 72˚ 42'E longitude (Greater Ahmedabad Integrated Mobility Plan). It is the commercial capital of the state and located on the proposed Delhi-Mumbai industrial corridor, thus being a destination of continued attraction for investors. It lies in the cotton belt of Gujarat, 500 km north of Mumbai and 96 km from the Gulf of Cambay. The Sabarmati River cuts through the city with the old walled city on its eastern banks and Mahatma Gandhi's Sabarmati Ashram on the western bank. It is a rapidly growing megacity; the population of the urban agglomeration including Ahmedabad city and its surrounding areas has increased from 3.31 million in 1991 to 4.5 million in 2001 (City Development Plan for Ahmedabad, 2006 - 2012; 17). The study focuses on the 43 wards of the Ahmedabad Municipal Corporation (AMC) which has a total area of 190.84 sq.km and a population of 3.5 million.

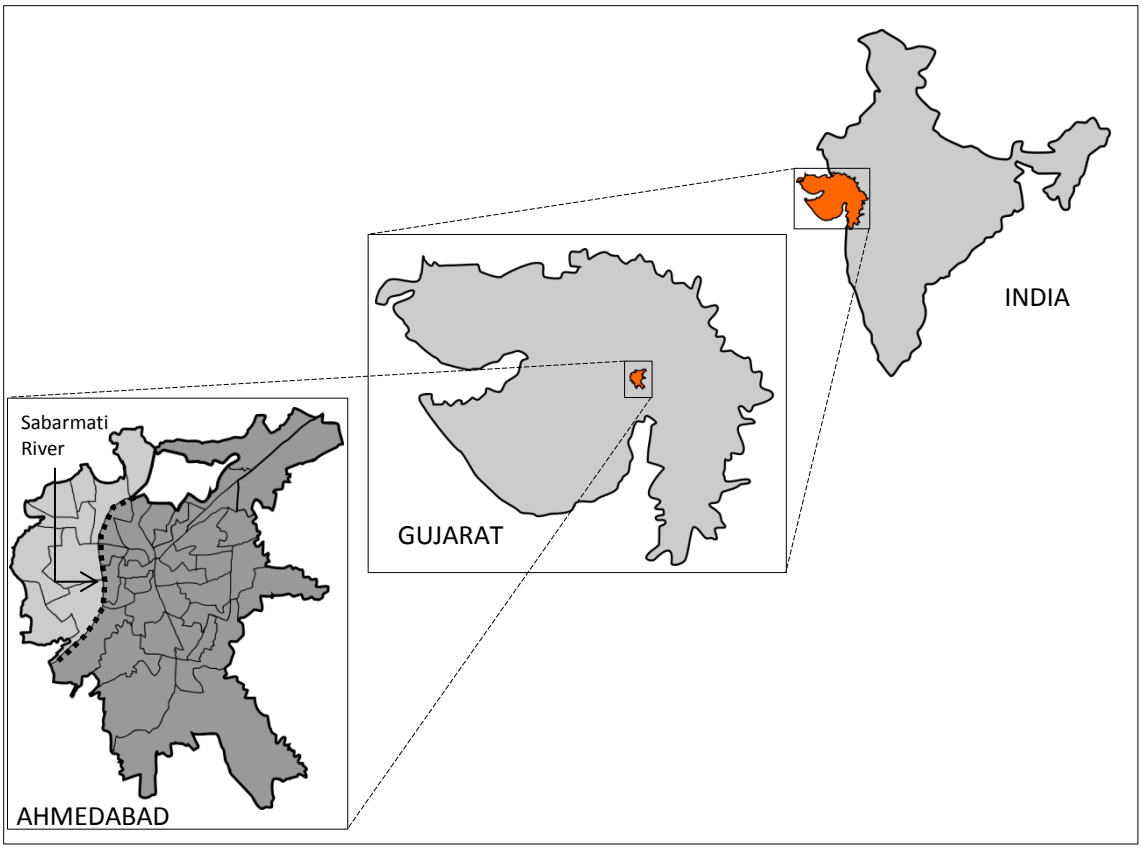


Fig. 6. 1 Location of Ahmedabad in Gujarat, India

6.1.1 Evolution of Physical Profile of Ahmedabad

The earliest mention of Ahmedabad is in 1411 when it was a small walled fort city on the banks of the River Sabarmati ruled by Sultan Ahmed Shah. In the 1700s, the city grew beyond its fort walls on the eastern banks of Sabarmati River, under changing political powers as it fell under the Maratha rule. It saw rapid urbanization during 1800 – 1950 when the booming Textile mill industry caused large scale in-migration which led the construction of large mills and thousands of new housing quarters for the mill workers. During this time bridges were built across the river and Mahatma Gandhi set up his ashram on the western banks of the river which had until now not been urbanized. This was also the phase when the Ahmedabad railway station was built and the first trains started running connecting Ahmedabad to Mumbai. After the Indian independence, from 1950 – 2000, new bridges were built across the river and old ones widened. Educational institutions were set up in western Ahmedabad and many community centres, and hospitals were built. The 2000s have seen the advent of large scale urban infrastructure development projects such as Sabarmati River Front Project and the Ahmedabad BRTS (winner of most sustainable transport service).

The AMC area constitutes of the traditional city core within the fort walls with a large concentration of formal and informal commercial activities and narrow alleys, the eastern area surrounding the old city walls with many industries and low income housing as well as the central railway station, and the western sector on the western banks of River Sabarmati, which is the planned part of the city with wider roads, institutions of higher education, and affluent residential areas. Ahmedabad's airport is located at the north east limits of the city near the cantonment area.

Ahmedabad changed from mono-centric to a polycentric form in terms of its social as well as religious landscape, just after 75 years of its foundation. Although the administrative head of the Gujarat Sultanate was transferred to another city; Champaner, at this time, Ahmedabad continued to prosper and remained the commercial and cultural capital of Gujarat. This attracted many immigrants from lands near and afar which resulted in a heterogeneous, polycentric demography.

Gujarat flourished with maritime trade with the beginning of the sixteenth century. Gujarati merchants visited and traded with Sri Lanka, Burma, Thailand, Indonesia, Africa, the Arabian Peninsula, and the Persian Gulf region. This not only enriched the port cities, but had a great effect on Ahmedabad's prosperity as it was the seat of power, a manufacturing centre and home to powerful merchants who financed and controlled this trade.

By the early seventeenth century, Ahmedabad was established as an important city in the world map known for its thriving commercial and manufacturing centres. This was further recognized by the entry of European trading companies. The liberal rule of the Mughals at the time also led to the development of new religious orders. Parallel to powerful sectarian and fundamentalist views, cries for the unity of religions and social harmony also emerged which gave the city its unique character in the first 300 years of its history.

After the fall of the Mughal Empire, Gujarat came under the Maratha rule before passing over to the British in the early nineteenth century, who used it only as a district headquarters. However, in 1861, city entrepreneurs introduced the textile industry to the city which earned it its nickname as the "Manchester of the East". The arrival of Mahatma Gandhi in 1915 was another addition to its multi-faceted identities when it became a centre of the Indian freedom struggle.

Several decades after the Indian independence, in 1960, Ahmedabad again became the provincial capital but after the formation of Gujarat state, the capital was shifted to the newly formed Gandhinagar thirty kilometres north of Ahmedabad. Today, in the twenty-first century, the medieval city of Ahmed Shah continues to expand in all directions and has acquired the status of a megacity.

6.1.2 Evolution of Socio-Political Profile of Ahmedabad

Ahmedabad was known as Karnavati up till the beginning of the 15th century, ruled by the Hindu Solanki rulers who had first settled on the banks of the Sabarmati River at the site of present day Ahmedabad. The city got its modern name in 1411 when the Muslim Muzaffarid dynasty was established in Gujarat and Sultan Ahmed Shah renamed Karnavati as Ahmedabad and established it as his capital city. In 1487 Mahmud Begada, the grandson of Ahmed Shah, enclosed the city with a fort of six miles in circumference and consisting of 12 gates, 189 bastions and over 6,000 battlements to protect it from outside invaders. This encouraged trade to flourish and was the inception of Ahmedabad's identity as a centre for commerce, which it holds to the present day.

After ruling for 162 years, the Muzaffar dynasty was defeated by the Mughal Emperor Akbar in 1573, as a result of which Gujarat and consequently Ahmedabad, came under the Mughal rule. Ahmedabad flourished as a centre for trade under the Mughal rule and became one of its most important cities especially famous for its textiles, which were exported as far as Europe. However the famine of 1630 and battles between the Mughals and Marathas in 1753 damaged the city a great deal.

After being under Maratha rule for 65 years, the British East India Company took over the city in 1818. A municipal government was established in 1858 and a railway link between Ahmedabad and erstwhile Bombay was completed in 1864. This was a time of rapid growth and development of the city and it regained its importance as a centre for trade and also became widely known for its vast textile manufacturing industry.

Mahatma Gandhi arrived from South Africa in 1915 and set up his Sabarmati Ashram on the western banks of the Sabarmati River. Ahmedabad consequently became an important centre for the Indian freedom struggle to gain independence from the British. During the 1960s the textile mills attracted a large migrant population from other parts of Gujarat. Ahmedabad's population grew by around 38% in the decade from 1961-1971 and a large part of this population settled in slum settlements in the eastern parts of the city near the textile mills. There had been some communal distress in the city in the past. These were heightened by the downfall of the textile mill industry when a large proportion of the mill workers were put out of job from the mid-1960s onwards. Seven large mills in Ahmedabad shut down and around 17,000 workers lost their jobs which led to economic insecurity, more in some communities than others, leading to violent clashes between Hindus and Muslims in the slums of Ahmedabad.

Since the independence of India in 1947, Ahmedabad has grown in a diversity of economic sectors into a vibrant city. However, about 35% of the city's population still resides in slums, *chawls* and squatter settlements. These slum dwellers are employed in a wide variety of jobs, primarily in the informal sector and belong to a diversity of religions, regions and communities thus enriching the social fabric of the city. The level of basic physical infrastructure, social amenities and governance is very low within these areas and insufficient to serve the resident population, which causes insecurity and has been manifested in the form of violent outbreaks at several occasions in the city's history.

6.1.3 Evolution of Economic Profile of Ahmedabad

The fortifications of the old city of Ahmedabad were the first impetus for economic growth of the city. It had flourished as a trade centre due to its close proximity to the sea port, the easy connection facilitated by the river and the safety afforded by the city walls.

The second phase of expansion of Ahmedabad was triggered by the establishment of the first cotton mill, which was set up in the old city area in Raikhad, in 1861. This was accompanied by the institution of the municipal government and railway link with Mumbai in 1864. This further facilitated the growth of the textile manufacturing industry and saw a huge swelling of the city's population caused by immigration from other parts of Gujarat and India. The city flourished and was dubbed as the "Manchester of the East" due to the glowing success of its

textile industry which reached its peak in the 1940s. After India's independence in August, 1947, diversification occurred in the city' economic base accompanied by growth of professional and technical institutions, such as the Physical Research Laboratory, the Indian Institute of Management, and the Centre for Environmental Planning and Technology, all on the western parts of the city.

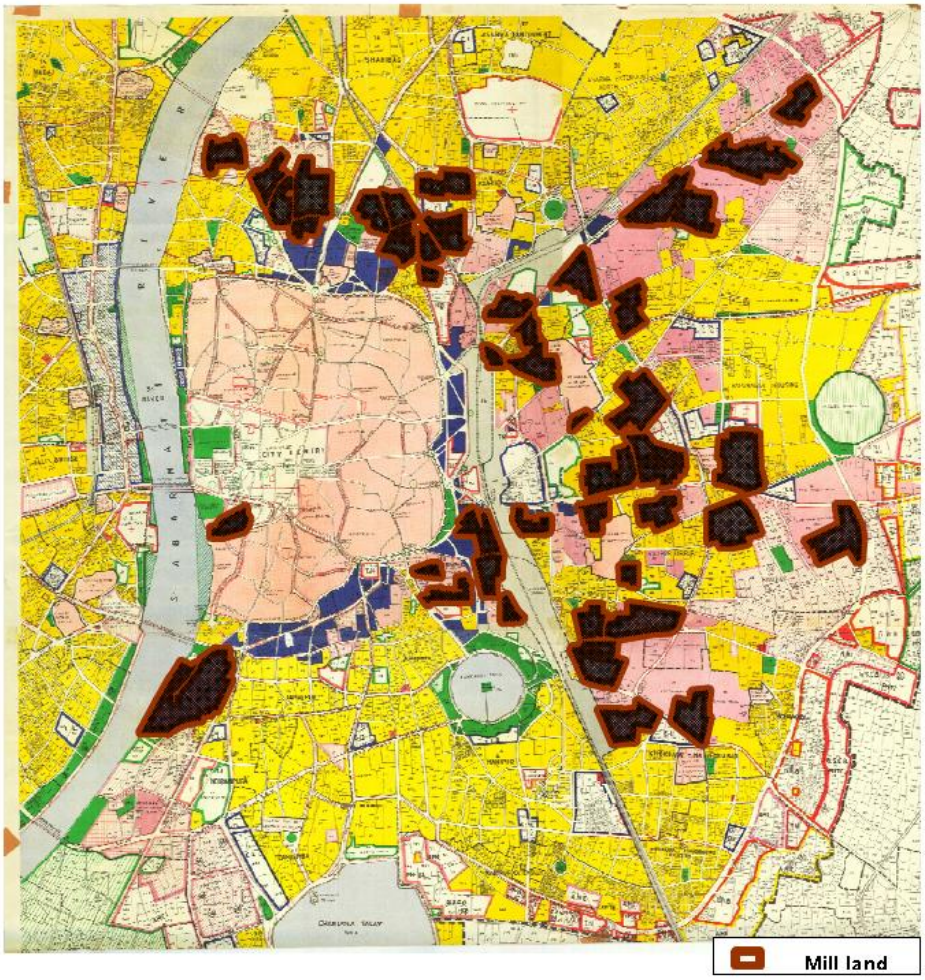
In an attempt to diversify the industrial base of the state to accelerate the pace of industrialization, the Gujarat Industrial Development Act of 1962, (GIDC) came into existence. The GIDC constructed ready to occupy sheds for immediate start-up of industries and additional storage facilities. These GIDC estates were self-contained sanctuaries capable of sustaining a large number of industries within themselves. 252 such estates have been planned by the GIDC of which 171 are operational today. In Ahmedabad, GIDC built industrial estates at Naroda, Odhav and Vatva in 1968, 10 kms outside the eastern fringe of the city which led to a significant diversification in the small and medium scale industries, related to engineering goods and chemicals (NIUA 2001).

The late 1970s and early 1980s saw the decline of the textile industry in Ahmedabad. This hit the city very hard, creating a very large unemployed population group plunging most of the city into extreme poverty. More than 60,000 people had lost their jobs, the large mill compounds formed ghostly patches within the centre city area (Fig. 6.2) and the mill workers *chawl* housing soon assumed the form of slums due to low maintenance and rising poverty.

In 1986, the boundary of AMC was extended to include the three industrial estates at Naroda, Odhav and Vatva. These industries had acted as growth centres for their surrounding areas for several decades. The undeveloped land between these growth poles and the city was urbanized and developed in the hope of using these industries to rejuvenate the failing economy (Damayanti *et al.,* 2009).

1991 marked the year of economic liberalization in India. This brought about a sectoral shift with a rapid growth of chemical and petrochemical industries in the south of Gujarat. The number of industries in and around Ahmedabad continued to decrease, however, an increase in tertiary sector was seen which included business and commerce, transportation, communication, construction activities and other services. The workers participation rate (WPR) of Ahmedabad city was 32%, at par with the state urban average of 33%. The share of the secondary sector had however dropped to 42% from the previous 50 %, in spite of the GIDC industrial estates. In terms of revenue generation in the secondary sector, chemical and petrochemical industries had the largest share, followed by metallurgical and engineering industries. The majority of employment in the secondary sector was however still in the textile

industry. The tertiary sector had clearly gained majority share absorbing 56% of the total main workers of the city (Census 2001). Less labour intensive secondary industries (such as metallurgical as compared to textile industry) and high skill level requirements of the emerging tertiary industry have resulted in a large unemployed population, which has been absorbed into the informal industry. The informal economy contributes largely to the economy and provides direct employment to 100,000 people and indirect employment to 300,000 people and creates business volume of approximately Rs. 40,000,000 every day. Central and eastern zones have lost employment opportunities in the formal sector. The informal economy needs to be recognized and supported to form a viable and secure source of income, especially in the central and eastern zones for the rejuvenation of the population of these areas.



The total land area occupied by the closed mills is **3.34 sq. kms.** Due to complex use change procedures and because of claims of Banks and workers the land is lying vacant since 1985/86.

Ownership	No. of closed mills
GSTC	18
NTC	5
Private	50
Total	53

Fig. 6. 2 Map showing Mill Areas in Ahmedabad
Source: City Development Plan for Ahmedabad 2006 – 2012, p. 23

7% of Gujarat's population resides in Ahmedabad which contributes 17% of the state's income (1995 figures). It is also a major industrial and financial city contributing about 14% of the total investments in all stock exchanges in India and 60% of the total productivity of the state. A private company operates a thermal power plant in the city.

A network of highways connects the cities of Mumbai and Delhi to Ahmedabad which forms an important development axis in western India. It is also well connected to other cities in Gujarat by road and rail linkages leading to an axial growth pattern emerging in the region. It has great promise in expanding its tertiary sector in the knowledge industry with world class institutions such as the Indian Institute of Management, National Institute of Design, Centre for Environment Planning and Technology (CEPT University), Physical Research Laboratory and Institute for Plasma Research, all located within the city.

6.1.4 Population Growth and Density Profile of Ahmedabad

The area selected for this research is the extents of the Ahmedabad Municipal Corporation (AMC). This consists of here main zones;

1. The old walled city area characterized by high-density development in the traditional style, narrow streets and a high concentration of commercial activities.
2. The Eastern Ahmedabad area populated by large and small scale industries and large tracts of low income residential areas.
3. The Western Ahmedabad area known for its well planned residential areas, wide roads, and major educational and research institutions.

The total population of AMC showed a rapid increase from 2.87 million in 1991 to 3.51 million in 2001 (City Development Plan for Ahmedabad, 2006 -2012). There has been a major shift in the spatial distribution of the population growth which was mostly concentrated within the eastern parts of the city until 1981, and on the eastern periphery. This was due to the textile mill industry located in this part of the city. However, since the 1980s with the downfall of the textile industry, the western part of the city has shown rapid growth, especially near the peripheral areas (Fig. 6.3). The higher rate of peripheral growth is due to existing high densities in inner city areas and large scale housing development near the periphery, especially in the western parts of the city. Ribbon development along the Sarkhej-Gandhinagar highway has also been observed since the 1990s (Fig. 6.4) and is expected to continue and further intensify in the coming decade.

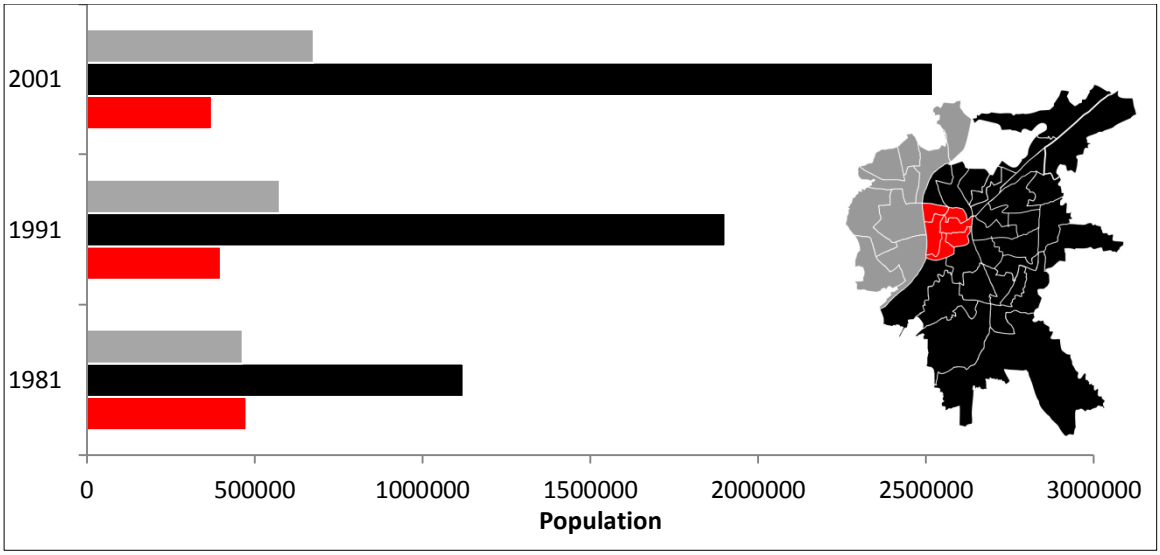


Fig. 6. 3 Spatial distribution of population growth in recent decades in Ahmedabad
Generated by Author using data from City Development Plan for Ahmedabad 2006-2012, table 2-1, p. 9

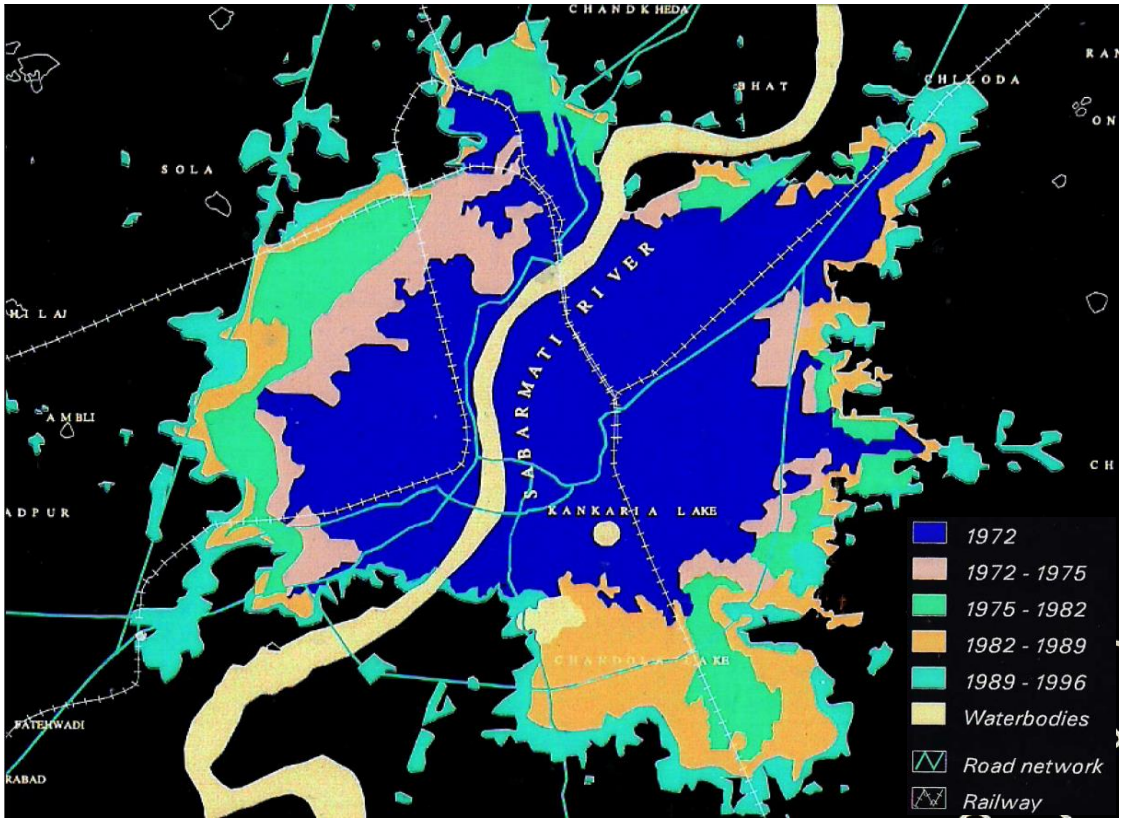


Fig. 6. 4 Ahmedabad Growth Pattern
Image Source: City Development Plan for Ahmedabad 2006-2012, p. 10

The density pattern of the city has been very compact. The walled city area is one of the most densely populated areas in the study area, and the stabilization of population growth in this area is largely attributed to the saturation of the urban density. The change in gross density in different parts of Ahmedabad is shown in Fig. 6.5. The rapid population growth illustrated in Fig. 6.3 has been accompanied by growth of the urban limits resulting in a less stark increase in

population density. The spatial distribution of population density in Ahmedabad is shown in Fig. 6.6.

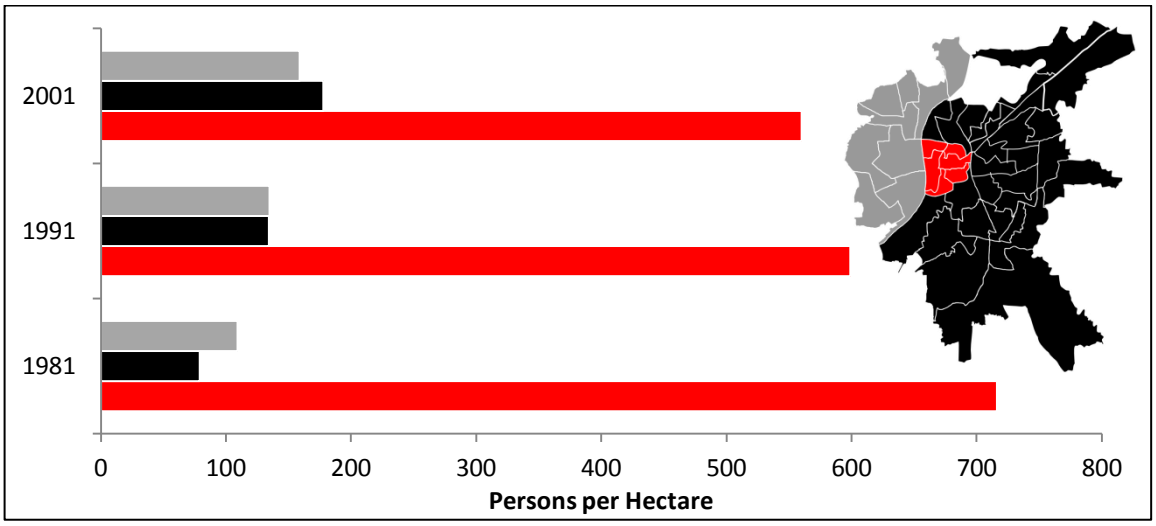


Fig. 6. 5 Decadal changes in Population Density in Ahmedabad
Generated by Author using data from City Development Plan for Ahmedabad 2006-2012, table 2-2 p. 13

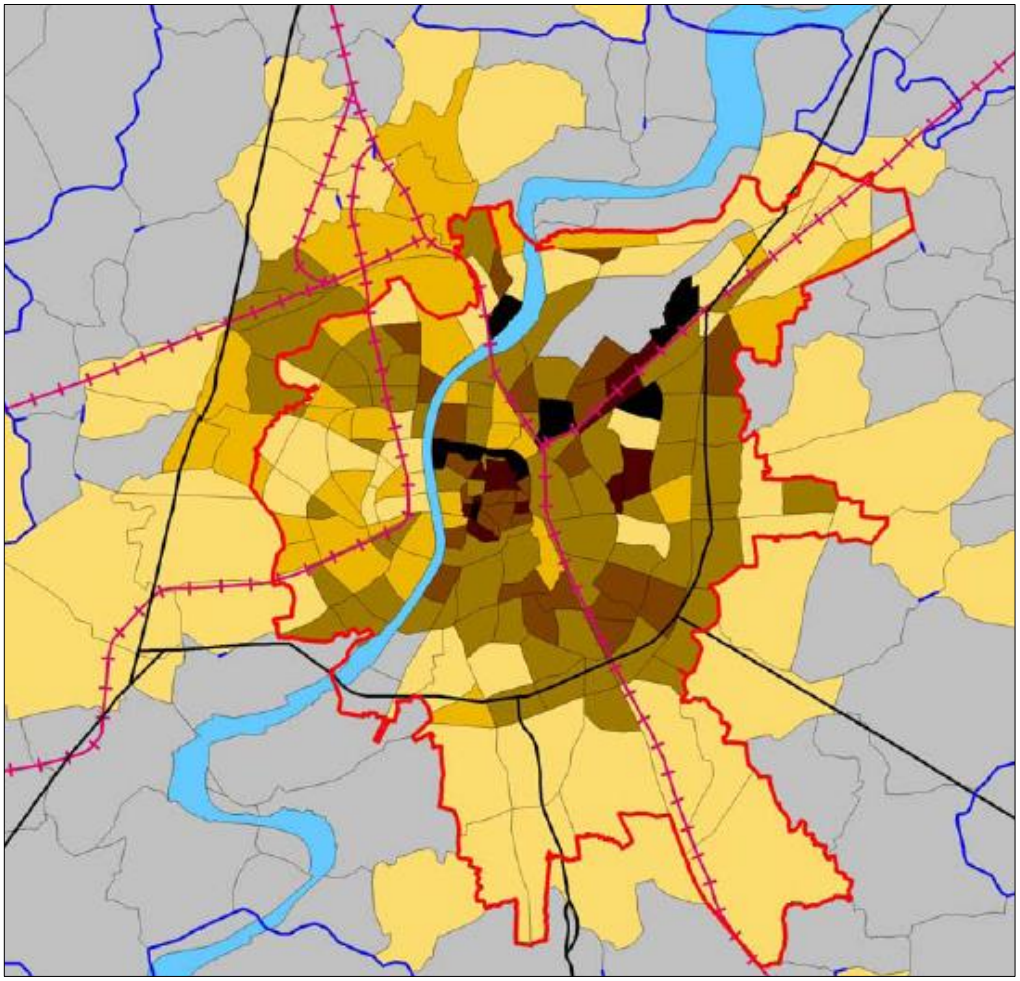


Fig. 6. 6 Spatial Distribution of Population Density in Ahmedabad
Image Source: City Development Plan for Ahmedabad 2006-2012, p. 12

From fig. 6.6 it is observed that the city has been undergoing contiguous growth, as rural land in the urban periphery increasingly gets converted to urban uses. This peripheral development has been occurring mostly along major physical infrastructure facilities such as road networks. Fig. 6.6 shows that a majority of such rural to urban transformation has been taking place in the western city limits.

6.2 Statistical Analysis of Ahmedabad

6.2.1 DM and DI of Ahmedabad

Ahmedabad posed a big problem in terms of data availability. Not all the DI and DM could be quantified as corresponding data was not available. The DI and DM that could be computed are detailed in Tables 6.1 and 6.2.

Table 6. 1 DI with corresponding datasets and data sources for Ahmedabad

		Dataset	Data Source
DEVELOPMENT INDICATORS			
1.	Economic Equity	% Regular Employment	Statistical handbook 2001
		% Unemployment	
2.	Health	Infant population	Census 2001
3.	Education	% literate	Census 2001
4.	Social Equity	Number of females per 1000 males	Census 2001
		Literate females per 1000 males	
		Working Females per 1000 males	
		Number of females per 1000 males of slum population	
		Number of female children per 1000 male children of slum population	Census 2001
		Slum Population %	

Table 6. 2 DM with corresponding datasets and data sources for Ahmedabad

		Dataset	Data Source
DENSITY MEASURES			
1.	Physical Density	Person/ sq.km	Census 2001
		Households/ sq.km	
2.	Amenity (Infrastructure Density)	% of households, with access to water tap	Census 2001
		% of Sewerage coverage of total ward	
3.	Autonomy (Job Density)	% of workforce in main employment in ward by average of city	Statistical handbook 2001

A unity – based normalization was applied to the data in order to be able to make comparisons between various DM, DI and within the wards. The mean of the group of data for each ward under each of the DI and DM were then calculated to give the values of DIs and DM for each of the wards. The mathematical expression for calculating each DI and DM from the corresponding datasets is shown in the previous chapter in equation 5.1.

6.2.2 Exploratory Analysis of Relationships between DM and DI

Each of the DI were taken as the dependent variable (y-axis) and plotted against each of the DM individually, in order to spot any obvious relationships (Fig. 6.7)

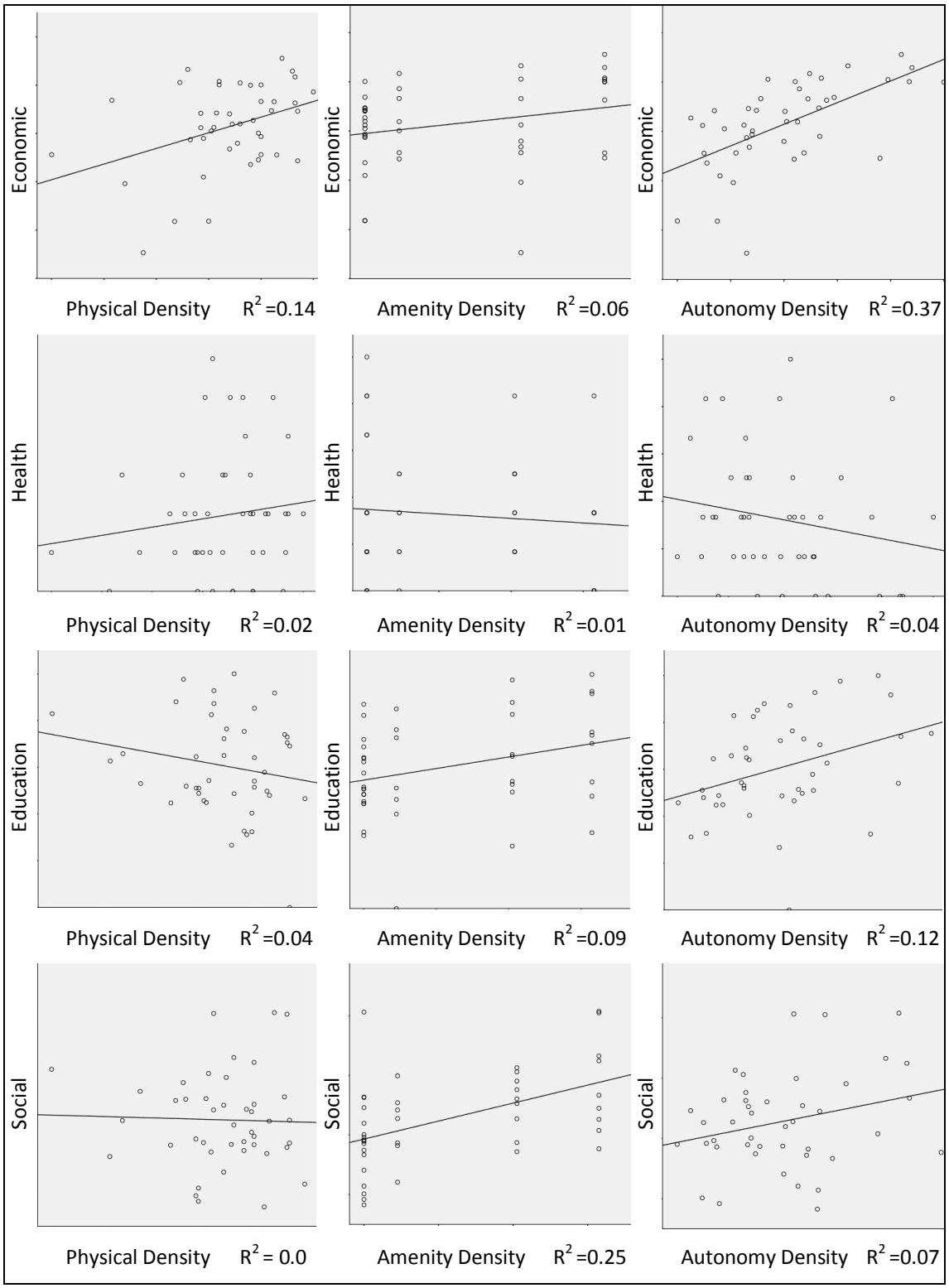


Fig. 6. 7 Scatter Plots of Composite DI with Individual DMs showing coefficient of determination (R^2) in Ahmedabad

A few linear trends were noticed in the data. Economic equity seemed to increase with an increase in physical density and autonomy density. Also, education levels showed an increase with an increase in autonomy levels.

The Pearson's correlation coefficients between each of the DI and DM were also found. It was found that all the DIs except for Health, was correlated with at least one of the DM as shown in Table 6.3.

Table 6. 3 Correlation Analysis for DI and DM of Ahmedabad

	Physical Density	Amenity Density	Autonomy Density
Economic Equity	0.378	0.245	0.605
Health	0.136	-0.094	-0.190
Education	-0.192	0.303	0.350
Social Equity	-0.031	0.496	0.269

Correlation is significant at the 0.05 level (2-tailed).

Correlation is significant at the 0.01 level (2-tailed).

6.2.3 Multiple Regression Analysis of Ahmedabad Data

A multiple regression analysis was carried out to determine the combined relationship of all the DMs on the composite DI. The composite DI was calculated as the sum of the means of the DI s of Economic Equity, Education, and Social Equity. Health was not included since it showed no correlation with any of the DMs (Table 6.3). The composite DI was taken as the dependent variable of the regression analysis and Physical Density, Amenity Density and Autonomy Density were taken as the independent variables. The R^2 of the regression model was 0.308 which is very low. However, in the absence of more data, this is all that was available. The regression coefficients are shown in Table 6.4. The sig. values of Physical Density and Amenity Density are 0.476 and 0.342 respectively which means that the regression model has an error rate of 47.6% and 34.2 % in predicting their role in calculating composite DI.

Table 6. 4 Regression Co-efficients for Ahmedabad

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.474	.069		6.840	.000
	Physical	-.071	.099	-.103	-.720	.476
	Amenity	.062	.065	.146	.962	.342
	Autonomy	.286	.093	.493	3.092	.004

In spite of the high error values and low R^2, the regression equation obtained from the above model was used to predict the DI of the wards of Ahmedabad (Fig. 6.9). The expected and observed residuals were plotted which showed very little deviation and no outliers (Fig. 6.8)

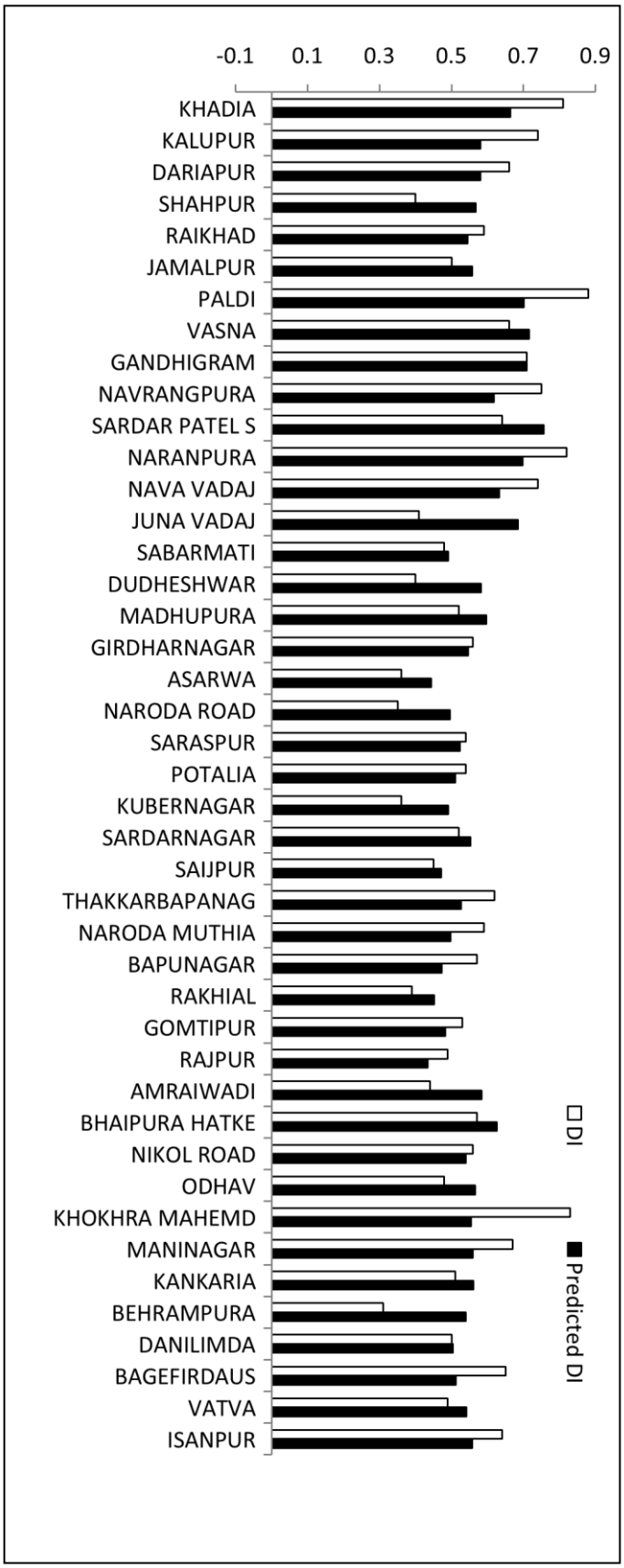


Fig. 6. 8 Plot of Actual DI and Predicted DI by regression equation for Ahmedabad

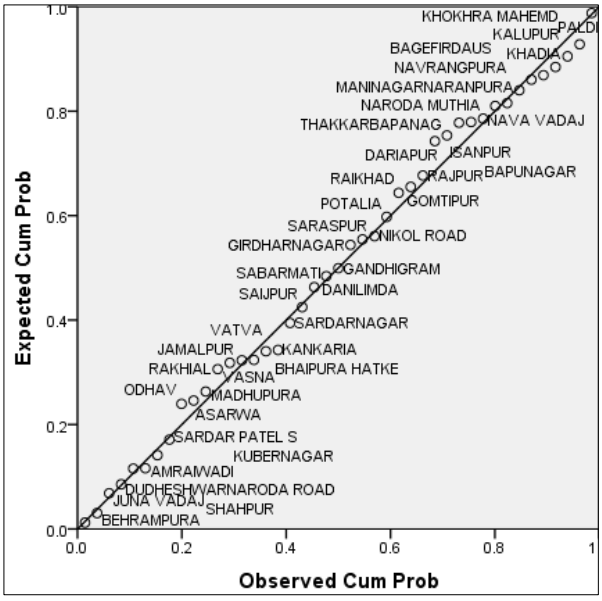


Fig. 6. 9 Normal P-P Plot of Regression Standardized Residuals for Ahmedabad

The regression equation found was:

$$Composite\ DI = 0.474 + 0.286 Autonomy + 0.062 Amenity - 0.071 Physical\ Density$$

Equation 6. 1 Regression Equation for Ahmedabad

6.2.4 Cluster Analysis using DI

As in the case of Mumbai, the clustering was done using the Ward's minimum variance method of hierarchical cluster analysis using squared Euclidean distance as the interval measure and composite DI without Health as the clustering criteria. The results of the cluster analysis are shown in Fig. 6.10.

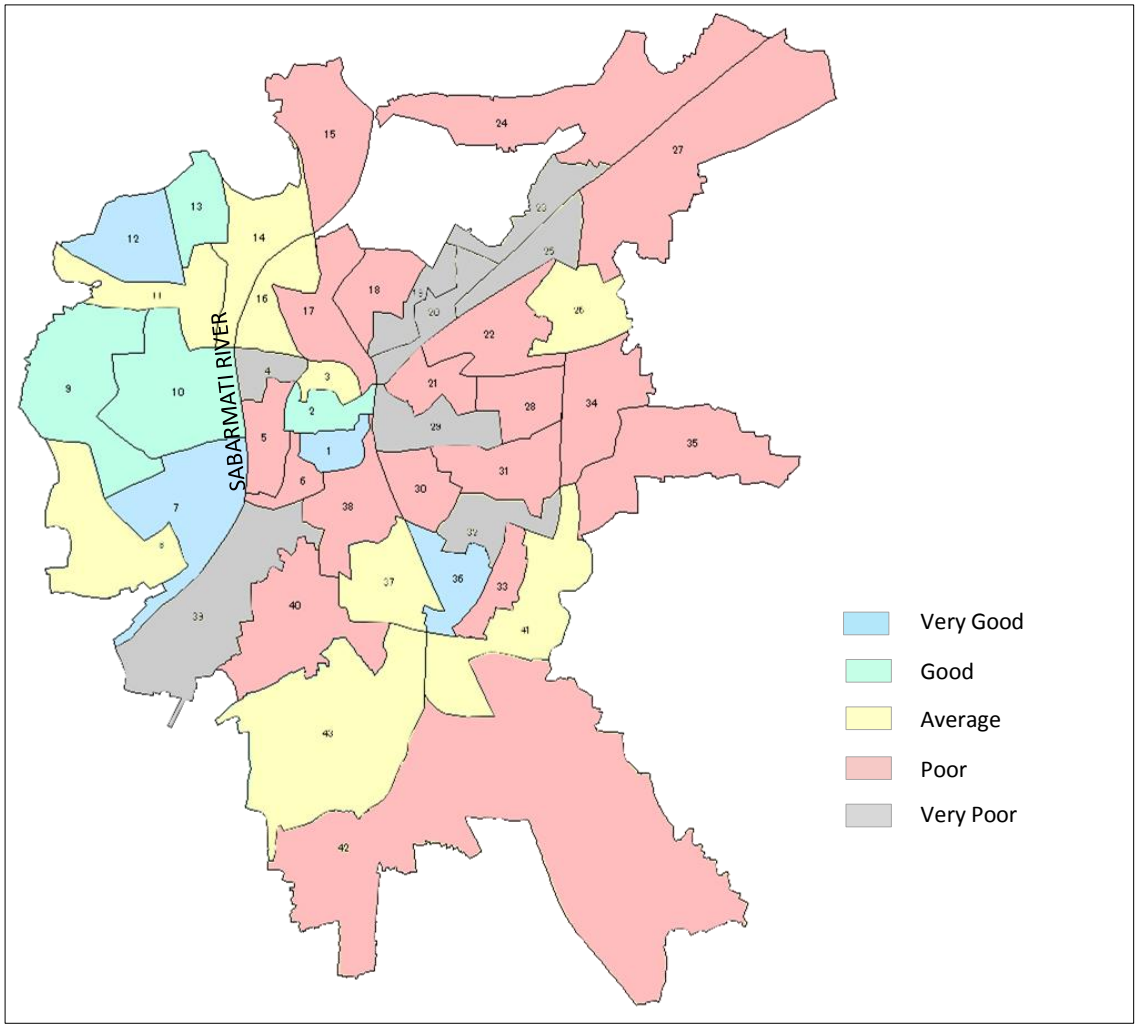


Fig. 6. 10 Cluster Analysis of Ahmedabad

A very clear spatial divide was aparent in the cluster analysis of Ahmedabad. A majority of the wards on the eastern side of the river Sabarmati were clustered into the very poor and poor DI clusters. The areas where textile mills once operated (Fig. 6.6), were especially highlighted as having very poor DI. The wards on the western side of the river however had high levels of DI.

This spatial distribution can be explained by the historical evolution of the city as discussed in the initial section of this chapter. The city originated on the eastern bank in the walled city area and grew outwards as a result of the growing cotton industry. Many *chawls* were therefore constructed on the eastern side of the city to house the mill workers. Once the textile industry declined, these *chawl* areas became run-down as the owners of the mills stopped investing on their upkeep. The unemployed mill workers continued to live in these *chawls* with their families and employed themselves in inforal jobs in the city. Struggling with uncertainty and poverty, the worker's residences soon became slums, which explains the poor DI found, of the inhabitants of this area. The western part of the city however, was laid out according to a well planned scheme, consisting well planned roads, healthy residential communities and world class institutions.

6.2.5 Inter-cluster variation of DI datasets

The mean DI values of the five clusters found in the previous section were, 0.84, 0.74, 0.65, 0.53 and 0.39, descending from the "Very Good" cluster to the "Very Poor" cluster. However, these values do not give a good idea of the actual status of the respecting ward clusters. In order to better understand the typical DI characteristics of each of the clusters, the cluster-wise mean values of the representative datasets that showed a Pearson's correlation coefficient of greater than 0.5 when correlated with the cluster-wise mean DI values, were plotted as bar-charts (Fig. 6.11). The cluster-wise minimum and maximum values of these datasets were also plotted to understand the cluster-wise degree of variance from the mean.

From the plots of cluster-wise mean values of DI data sets it can be said that areas of **high slum population, high unemployment, low average number of females per 1000 males, and low literacy** as compared to the rest of Ahmedabad, are the **areas of low human security**. It therefore also follows that these are the areas which need prioritized planning interventions to improve the human security of the inhabitants.

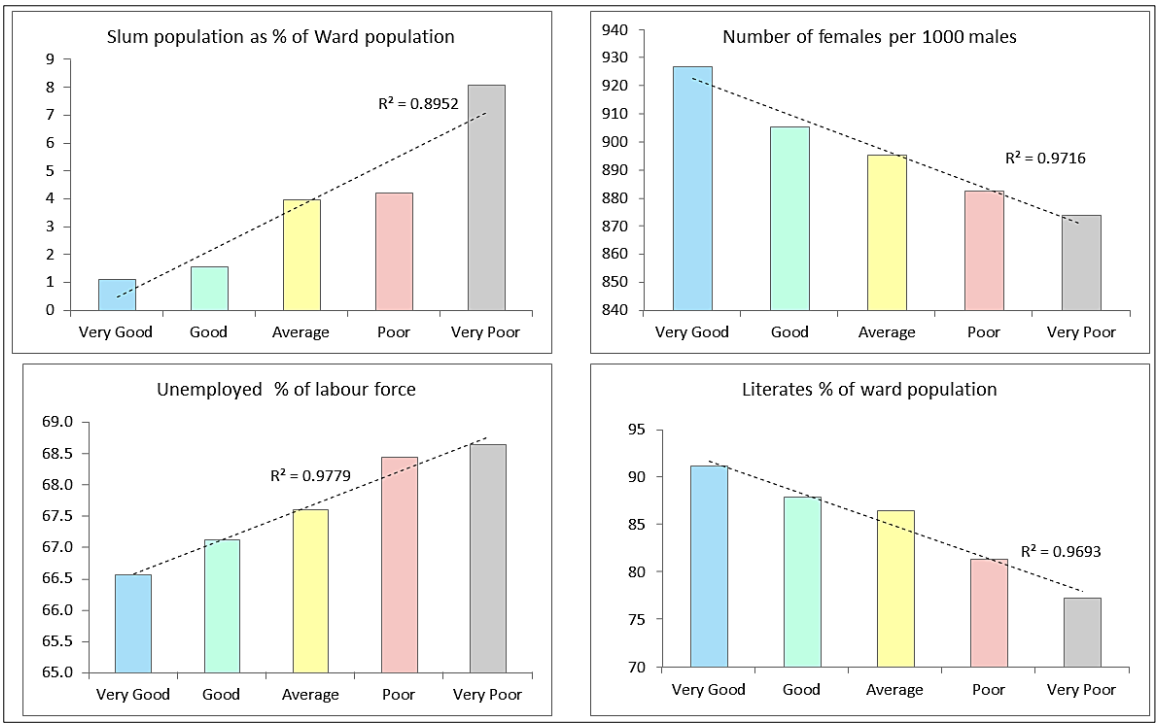


Fig. 6. 11 Cluster wise mean variation in DI datasets for Ahmedabad

6.2.6 Variations in DM datasets corresponding to DI clusters

The DI datasets characteristic of each DI cluster having been identified, a similar exercise was carried out for the cluster-wise mean of DM datasets. The DM data sets that showed a high correlation with cluster-wise mean DI values were:

- Sewerage coverage % of total ward households
- Local Employment Ratio
- Water Supply coverage % of total ward households
- Gross Household Density
- Gross physical Density

The cluster-wise mean, minimum and maximum values of each of these datasets were plotted as shown in Fig. 6.12. From the plot of cluster-wise mean values of DM datasets (Fig. 6.12) it can be said that the datasets corresponding to Amenity; Sewerage and Water supply coverage, and the data set corresponding to Autonomy; i.e., Local Employment Ratio, have a strong positive linear relationship with DI. Gross density measures of population and household show a negative linear relationship with DI. This negative linear relationship is however only seen in the cluster wise mean values and minimum values in each cluster. The maximum values do not follow this trend. As data for floating density could not be obtained at the ward-wise level, the DM of Floating Density has been excluded from the analysis.

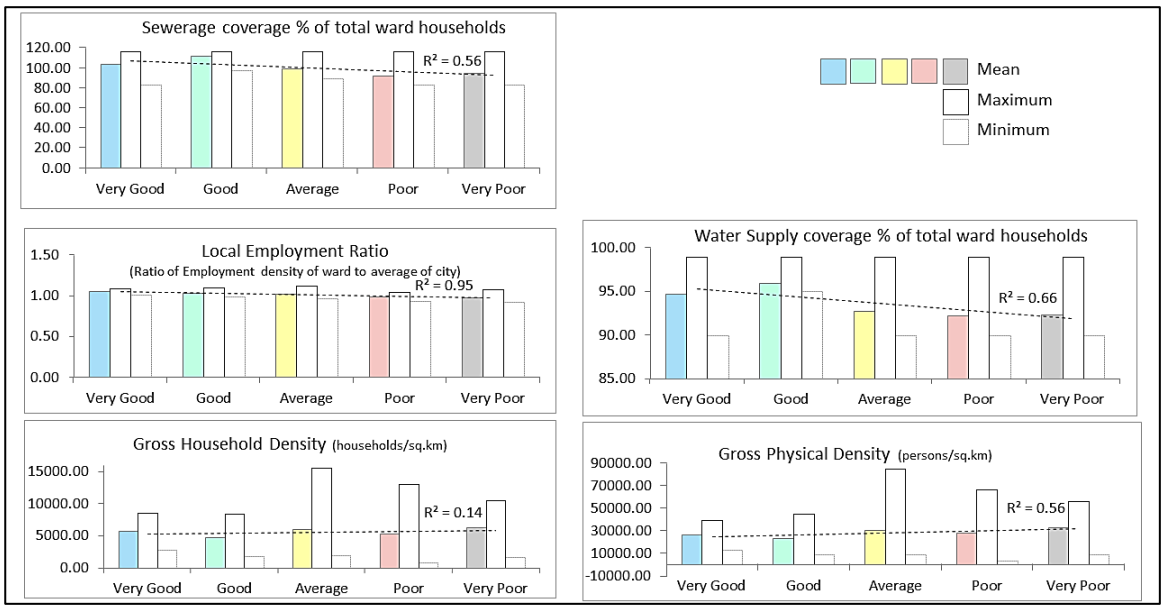


Fig. 6. 12 Cluster wise mean variation in DM datasets for Ahmedabad

Nevertheless, it is important to note the values corresponding to the very poor DI cluster. An average of 95.3% of even the worst DI wards are covered by sewerage connections, 92.3% have access to water supply and the employment ratio is 0.98. These are all very high values considering they correspond to the worst areas in a city of a developing country.

6.3 Discussion

The results of the statistical analysis prove that a relationship between DM and DI does exist in the wards of Ahmedabad, for data from 2001. The regression equation for this relationship is;

$$Composite\ DI = 0.474 + 0.286 Autonomy + 0.062 Amenity - 0.071 Physical\ Density$$

Additionally, the cluster analysis showed that the wards of lowest DI are the areas of dilapidated mill areas which are desolate places surrounded by the erstwhile mill worker residences, now in slum like conditions.

In Ahmedabad, low human security was characterized by high numbers of ward population residing in slums, high rate of illiteracy, low number of women as compared to men, and high unemployment rates just as in the case of Mumbai. It is however very important to note one big difference in the two cities and that is the astronomical difference in the number of people residing in slums. Less than an average of 9% of ward population live in slum areas even in the wards of worst human security in the case of Ahmedabad whereas, around 80% of ward population resides in slums in the worst wards of Mumbai. Also, although the unemployed percentage does increase linearly from the best cluster to the worst, the difference between

the two extremes is very small. Therefore, gender inequality and literacy are the real threats to human security in Ahmedabad.

The DM trends associated with low DI in Ahmedabad were low sewerage and water supply amenity and low autonomy however, the level of amenity coverage was very high (above 90%) even in the wards of worst DI, as was the local job ratio (0.98). It is predicted that density of municipal schools as a measure of amenity and female work participation as a measure of autonomy could provide better insight into the inter cluster disparity.

As in the case of Mumbai, in Ahmedabad too, Crowding of infrastructure, jobs and physical space had a negative effect on Human Security. A planning approach for increasing social choices and integration while addressing the physical aspects of capacity expansion simultaneously would provide a lasting solution for the city.

6.3.1 Slum Networking

The national policy for identification and subsequent improvement or clearance of slum areas defined by the "Central Slum Areas (Improvement and Clearance) Act 1956, has been adapted or modified in different ways in the different states of India. In case of Gujarat and Ahmedabad, a number of policy and programme initiatives taken had subsequently changed the focus from clearance to up-gradation of slums and also a deeper understanding of what a slum is. Instead of just associating slums as areas of low amenity levels and inadequate built structures, they were seen as areas of complex socio-economic, political, cultural and human issues which needed to be addressed. This was a definitive step towards addressing the human security of slum residents. Additionally, a range of responses was also put forward to deal with this complex set of issues, which included education, awareness, individual and community motivation, community organization and mobilization to promote collective and cooperative group action; and planned intervention for income supplementation and creating conditions for sustainable change. (see: Planning Commission Task Force on Housing and Urban Development (1983), Report on Shelter for the Urban Poor and Slum Improvement, Government of India; our source: Dutta 2002). In other words, the focus was on increasing the capabilities of each individual, household and community by empowering them with the tools required for them to have a choice in the way they wished to lead their lives. This is a much better approach than just the provision of adequate water and sanitation as it gives people the tools to come out of poverty and therefore produce sustained benefits for the city.

6.3.2 Sanjay Nagar Slum Networking Pilot Project

The approach adopted in Ahmedabad was practiced through the Slum Networking Project (SNP), initially conceived as a pilot project but later adopted for many other areas owing to its success. The initial pilot project involved a slum pocket called “Sanjay Nagar” with a population of 1200 people (although 3 other slums had been selected for inclusion in this pilot project, the other slums dropped out from the project). The stakeholders in this project were; the slum dwellers, the Ahmedabad Municipal Corporation (public sector), an NGO (Non-Governmental Organization) called SAATH, and Arvind Mills Ltd. (private sector). The public sector played the role of the facilitator and together with the financial support of the private sector, carried out the physical development aspect of the project. This included the construction of internal roads and pavements, storm water drainage, street-lighting, solid waste management and landscaping. It also involved improvements in the basic infrastructure which was a deviation from the traditional approach of improving housing tenements. Water supply and toilets were provided on an individual household level rather than common water taps and community toilets that were the norm for slum improvement projects. The improvements in individual tenements were made by the slum dwellers themselves with investments of Rs. 10,000 per household. A marked improvement in the physical environment was also seen, maintained by the residents themselves.

Another area of focus was community development, carried out by the NGO SAATH. This involved setting up neighbourhood and women's groups, youth activities, mobilising community savings, educational activities for pre-primary age children and illiterate adults, organising community health, education, mother and child care, supporting income-generating activities, and developing linkages with the finance sector to access finance for small business and trade. These community interventions were very effective and produced a marked improvement in the health of the residents, a greater appreciation for education reflected in an increase in the level of school enrolment for children. Women found more time to attend to household activities and help their husbands in vending etc.

The project was launched on August 5, 1996 and completed by April 1997 at a total cost of Rs. 2.5 million. However there are several reasons due to which this model of slum improvement has not been adopted in more areas in Ahmedabad, as discussed:

1. Replicability of the project is a problem due to the absence of a legalized institutional structure defining the exact roles for the private, public, non-government and community actors. No such framework exists due to which it cannot be applied on a large scale across the city with transparency and local adaptations.

2. SNP has not been included in the city's overall planning scheme by the AMC. There exists no unified plan for city-wide implementation or for identification of slums to be included, standard timetable to be adopted, and sources and amount of finances used.
3. The slum-dwellers are granted secure tenure of up to 10 years as part of the SNP. This reinforces residents' perception of a lack of commitment by the authorities and also discourages many residents from making monetary investments as they feel that it will be taken away from them in the long run. Lack of secure tenure therefore lessens the level of commitment of the residents, which is the most important factor for the success of the SNP.
4. There is a dearth of NGOs with suitable capacity and experience required for the challenges of the SNP. The success and sustainability of these projects is largely dependent on community development activities and so, NGOs are a very important component of the partnership. Two strong NGOs that have been deeply involved – SEWA/MHT and SAATH cannot cover the whole city, nor can they build rapport quickly when they enter new SNP neighbourhoods.

The SNP addresses all of the DI s previously framed in this research, through community development carried out by the NGOs, as illustrated by Fig. 6.13. Apart from these interventions, the amenity level is increased through the partnership of the public and private sectors.

A development model focussing on the DI s has shown great promise and sustainable results. A legal framework for structured implementation will allow the project to be replicated for other slum communities and benefit a larger population. It must also be mentioned that although the focus on DI has been the major component for the sustained success of this project, this has been accompanied by improvements in the DM levels of the slum area. The amenity density and autonomy density, which were identified to have the strongest relationship with DI, were both strengthened. The amenity density was strengthened through the construction of water supply and toilets for each individual household. The autonomy density was strengthened by providing support and financial security to the informal enterprises of the slum dwellers, reducing the vulnerability of their livelihoods and helping them be securely employed in close proximity to their residence. In the absence of these steps to improve the amenity and autonomy, the low value of these DM would intensify the issues related to low human security and be preventive in the actions of the NGO discussed in Fig. 6.13, from fully taking effect. For example, in the absence of stable employment, children are often forced to become an earning member of the family which keeps them from attending school.

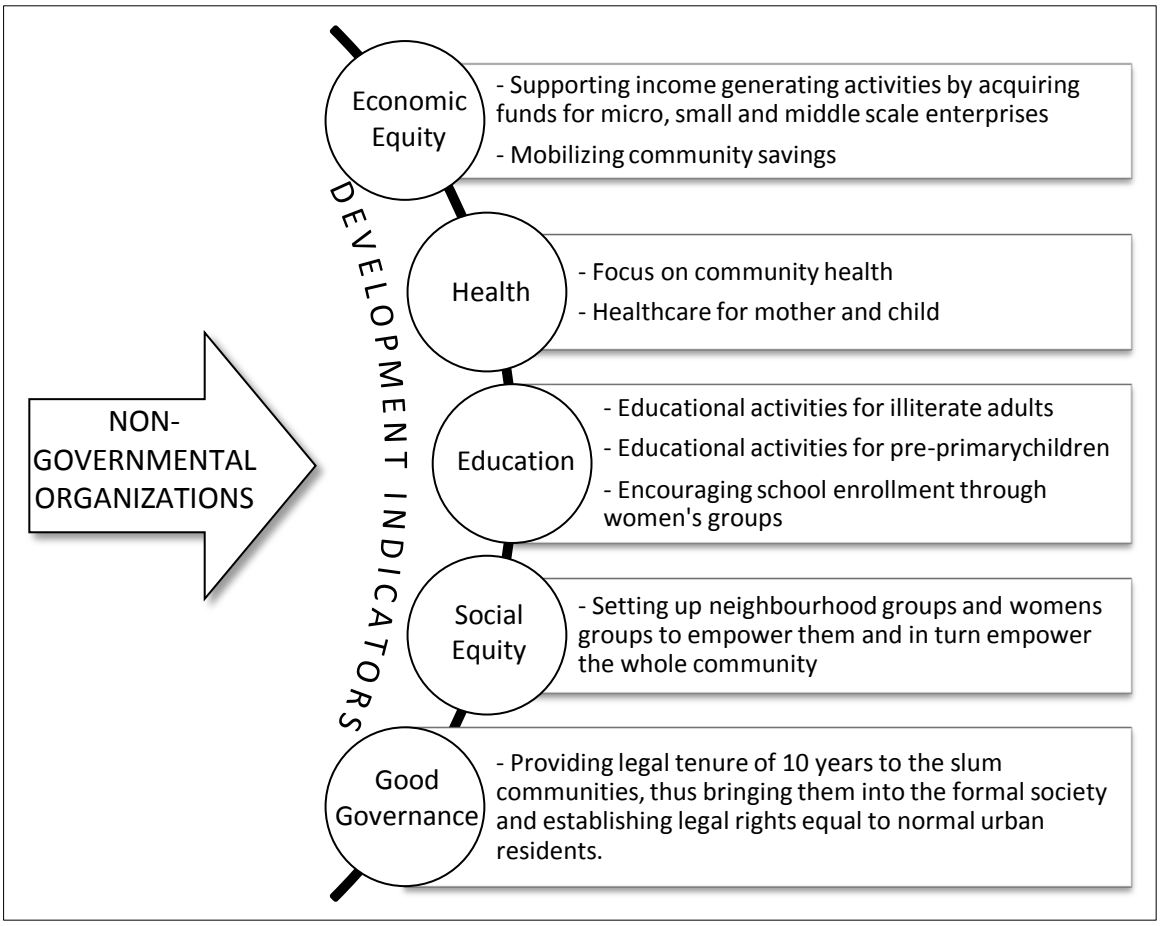


Fig. 6. 13 The role of Non-Governmental Organizations in improving the Human Security of Slum residents, through community development in SNP

Also, when water is not available legally in close quarters, women often have the responsibility to fetch water for the household from long distances. They are also forced to defecate in the open in the absence of private toilets, since public toilets are usually too unhygienic as they are not maintained. Both of these situations are extremely damaging to women's security. Not only does their health suffer severely, but they also continuously live with the fear of falling victim to rape as most slum dwelling women choose to defecate under the shadow of darkness in the desperate need to protect their privacy.

Improvements in the DM measures, especially those related to lower DI, are therefore extremely necessary to create the right environment for improvement of DI.

6.4 Conclusion

An investigation of the relationship between DI and DM has been carried out in Ahmedabad using the same methodology previously applied to Mumbai. As with the previous case of Mumbai, several objectives of this research have been achieved in this chapter. These are explained below:

1. The **third objective** of this research, which was to successfully apply the DM and DI to adapt them according to data availability and the historical, economic, political and social context of the city, has been **achieved in this chapter** for the case of Ahmedabad. Secondary data collected from a wide range of sources have been used to compute the DM and DI which reflect the urban density conditions and human security conditions of the city.
2. The wards of poor human security have been identified. Furthermore, the characteristics that define low security have been recognized as **high slum population, high unemployment, low average number of females per 1000 males, and low literacy.** The density features that corresponded to areas of low human security have been found to be **low sewerage coverage**, **low local employment** ratio, **low water supply** coverage and **higher gross physical density** in comparison to other areas of the city. However, **these DM data trends cannot be labelled as causes of low human security** because there is no conclusive data to prove it, and very little difference in the actual levels of these DM datasets in good and poor security clusters. What can be concluded definitively is that areas of high slum population, which have the lowest human security, are also the areas characterized by lower physical infrastructure, higher gross densities and lesser number of people employed in main sector jobs. The DM data trends define the typical conditions in slum areas which have low human security. However, as illustrated by the DI data analysis, **both slum and non-slum areas of poor gender ratios, low literacy levels and a greater number of people engaged in the informal sector, brings about lower levels of human security** in the city.
3. The analysis of Ahmedabad has shown that a basic level of the Density Measures is required in the city. However, effective development, improvement of human security, and sustainable urbanization where each urban resident is capable of leading a life of their choosing, can be achieved by focusing on strengthening the Development Indicators, as practiced by the Slum Networking Project.
4. The relationship between DM and DI has been found as discussed above and the spatial distribution of DI clusters has been established, **achieving the fourth and fifth objectives of the research.**

6.5 Way Forward

6.5.1 Need for micro level analysis

As stated in the case of Mumbai, the problem with ward level data analysis is that wards with higher share of slum population are identified as areas of poor human security. The vulnerable areas within other wards are not identified if the same ward has a higher share of non-slum population, which increases the overall score of DI of the ward.

As already discussed, **poor DM values are not necessarily the cause for low DI however; very poor levels of DM intensify the issues related to lower DI levels**. A micro level analysis to identify standard urban typologies representative of inadequate DM levels is therefore necessary. The identification of such standard urban typologies can then help to easily identify poor DM areas which stand a greater probability of having low DI. **Such areas identified all over the city**, can then be studied and projects such as the SNP, which target the **improvement of DI levels** along with improvements in the DM levels, can be implemented.

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Chapter 7:

STUDY AREA: TOKYO

"More than any other city, Tokyo demonstrates that 'city' is a verb and not a noun"

- *Mori Toshiko*

7.1 Introduction to Tokyo and its Urban History

The city of Tokyo is located on the Eastern coast of Japan (Fig. 7.1) geographically situated between 35° 30′ N and 35° 30′ N and 35° 48′ N latitude, and 139° 33′ E and 140° 01’ E longitude . It is the financial and administrative capital of the country as well as the residence of Japan’s Imperial family. The Tokyo Metropolis is one of the largest and most complex urban systems in the world measuring 2177.35 sq.km with a population of 12 million. This vast urban area has various different density characteristics and urban systems within it. This research focuses on the 23 Special Wards of the Tokyo Metropolis, characterized by its extremely high population density.

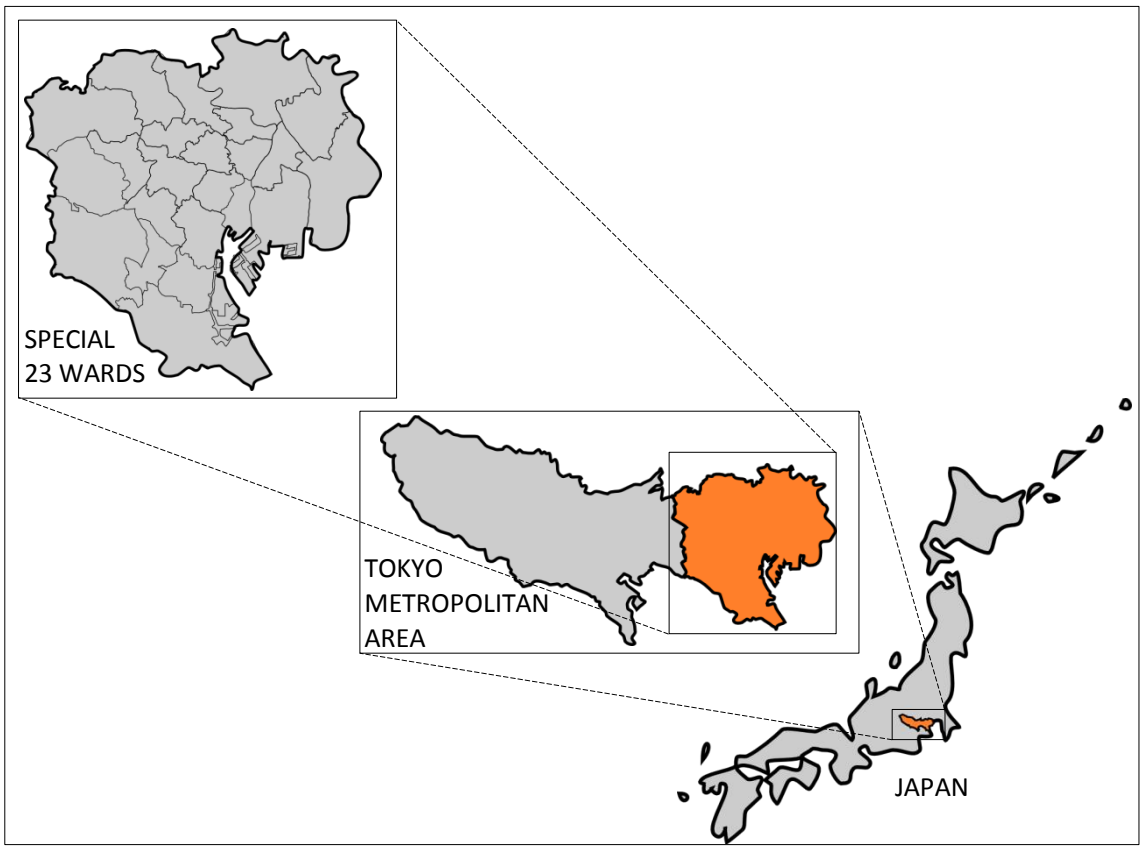

Fig. 7. 1 Location of Special 23 Wards of Tokyo, in Tokyo Metropolitan Area, in Japan

7.1.1 Evolution of Physical Profile of Tokyo in relation to Evolution of Socio-political Profile

The urban history of the Special Wards of Tokyo spans over 3 main phases of Japanese history that have helped to shape its urban form; the Edo, Meiji and Late Taisho/Early Showa Periods.

Edo Period

Originally a small fishing village, it was acquired by the Edo clan who first fortified it in the late twelfth century. The Tokugawa clan made Edo their base and when Tokugawa Ieyasu became the shogun on 24th March, 1603, Edo became the centre of power from where the entire country was ruled.

This is the time when the first spatial differentiation of urban form occurred on the basis of social classes. The Edo castle, the seat of power was located on the edge of the Musashino Plateau (Fig. 7.2). There were many ridges and valleys on the plateau surrounding the castle. The ridges and uplands were strategically safer from enemy attacks and facilitated surveillance of the surrounding landscape. These uplands were inhabited by the powerful daimyo residences and other wealthy and powerful families. The lowlands surrounding the uplands were in the valley of rivers and streams and proved suitable for agriculture. The peasants lived in the valleys where they practiced farming and also were close enough to the rich families to employ themselves as their servants. The area to the north of the Edo Castle, the Johoku, was home to the rich and powerful in the uplands and the peasants in the valleys. The area to the west, Josai, was the middle and lower class warriors' district and the area to the south, the Jonan, had complex topography with many steep ridges inhabited by the Daimyo establishments. Thus the spatial separation between the social classes occurred, giving different meanings to the "high city / low city" and to "hillside / waterside".

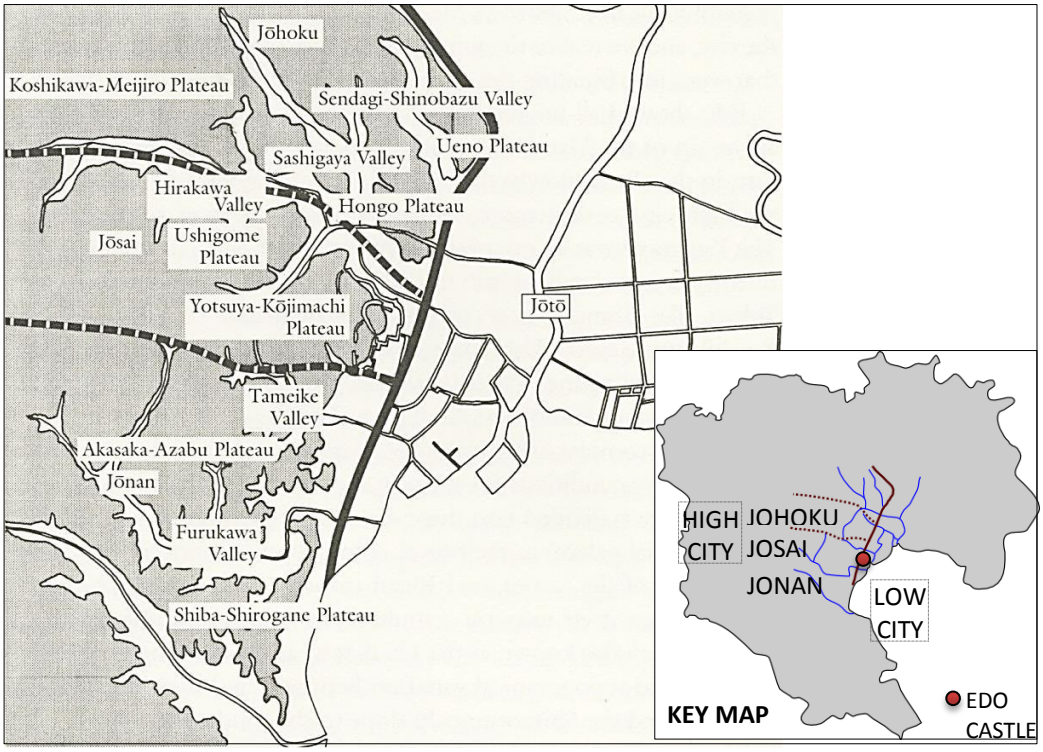

Fig. 7. 2 Spatial zoning of Social classes along Topographical features in Edo
Image Source: Jinnai Hidenobu, Tokyo: A Spatial Anthropology

Edo flourished in the time between its founding as the seat of power in 1603 to its downfall in 1657. Trade prospered and the population grew exponentially soon making Edo a million plus city. Edo was still essentially a fort city under tight control and so its spatial expansion happened systematically. It was the practice of the day to build temples in the city periphery along the main trade routes that led from the city. These temples served as guard posts and were points of control. They naturally had nodal quality and attracted small villages to be set up in their surroundings engaged in various economic activities linked to the temples. These development activities merged with the main urban area with time and the city boundaries were therefore progressively extended inwards into the country (Fig. 7.3).

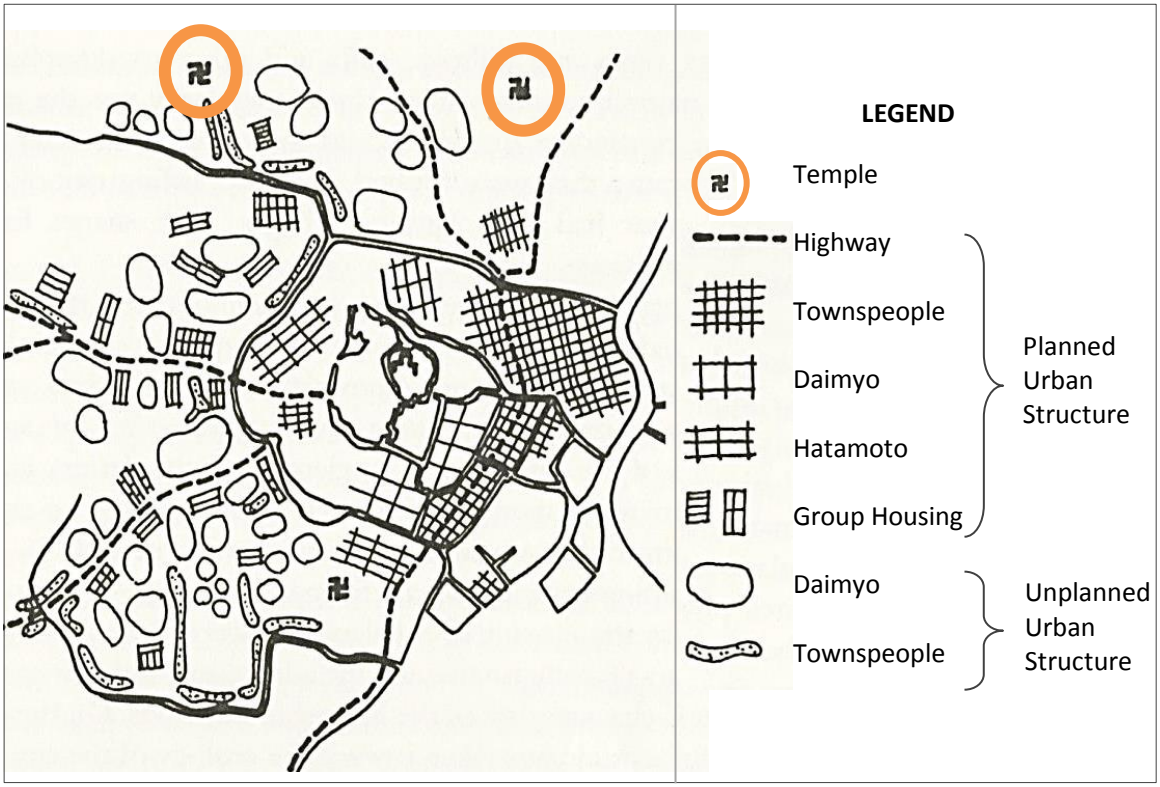

Fig. 7. 3 Temples as Urban Growth Nodes in Edo
Image Source: Jinnai Hidenobu, Tokyo: A Spatial Anthropology

The area between the Musashino Plateau and the sea, a low lying area crisscrossed by multitudes of canals formed by the backwaters of the sea provided the perfect logistics for merchants (Fig. 7.4).

This area was therefore densely packed with trade and commerce activities. This gave impetus to the entertainment industry which consequently emerged among the canals in this area (Fig. 7.5).

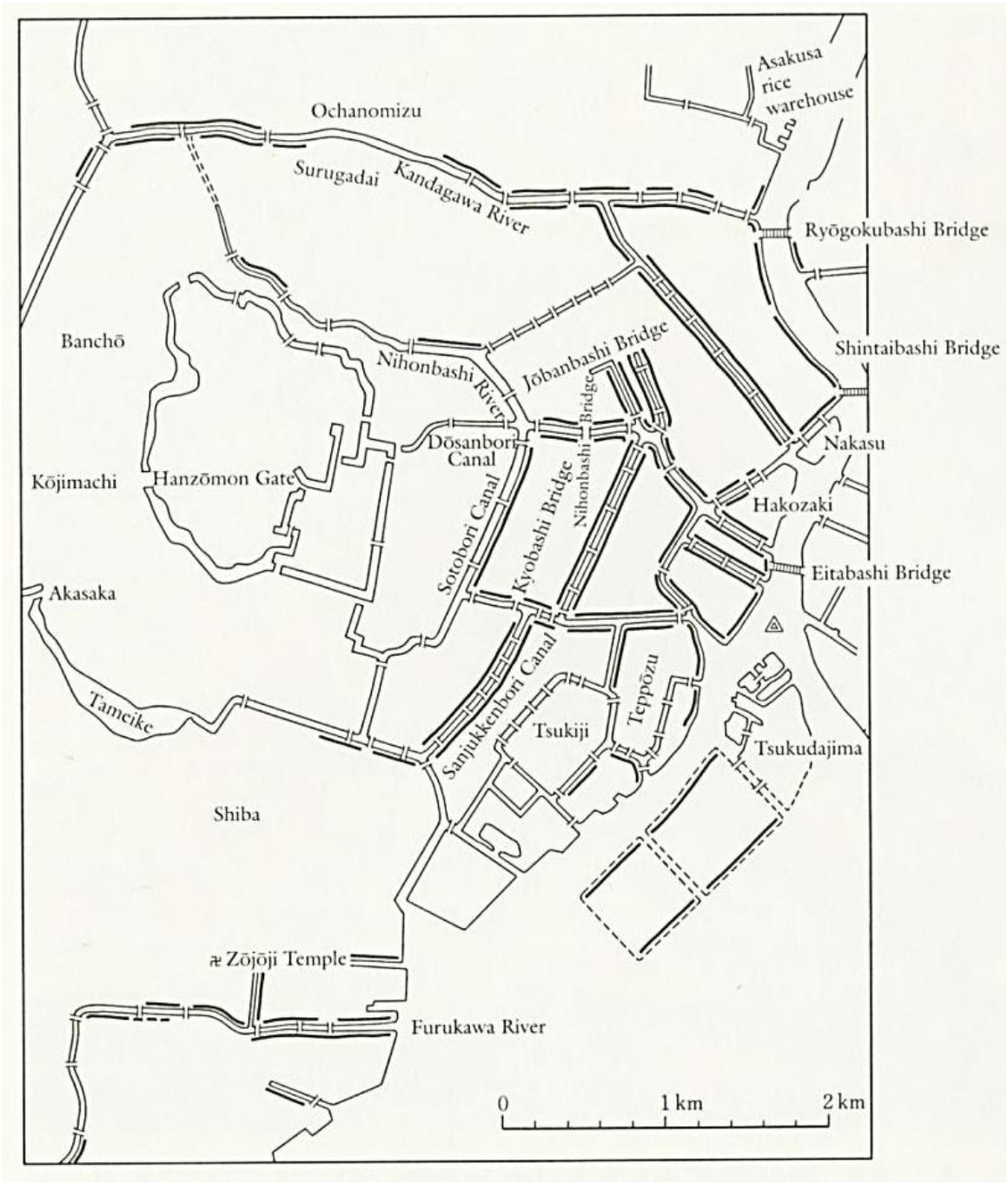

Fig. 7. 4 Edo's canals and waterfront in the middle of the nineteenth century
Image Source: Suzuki Masao, Edo no kawa, Tokyo no kawa (Rivers of Edo, Rivers of Tokyo). NHK Books.

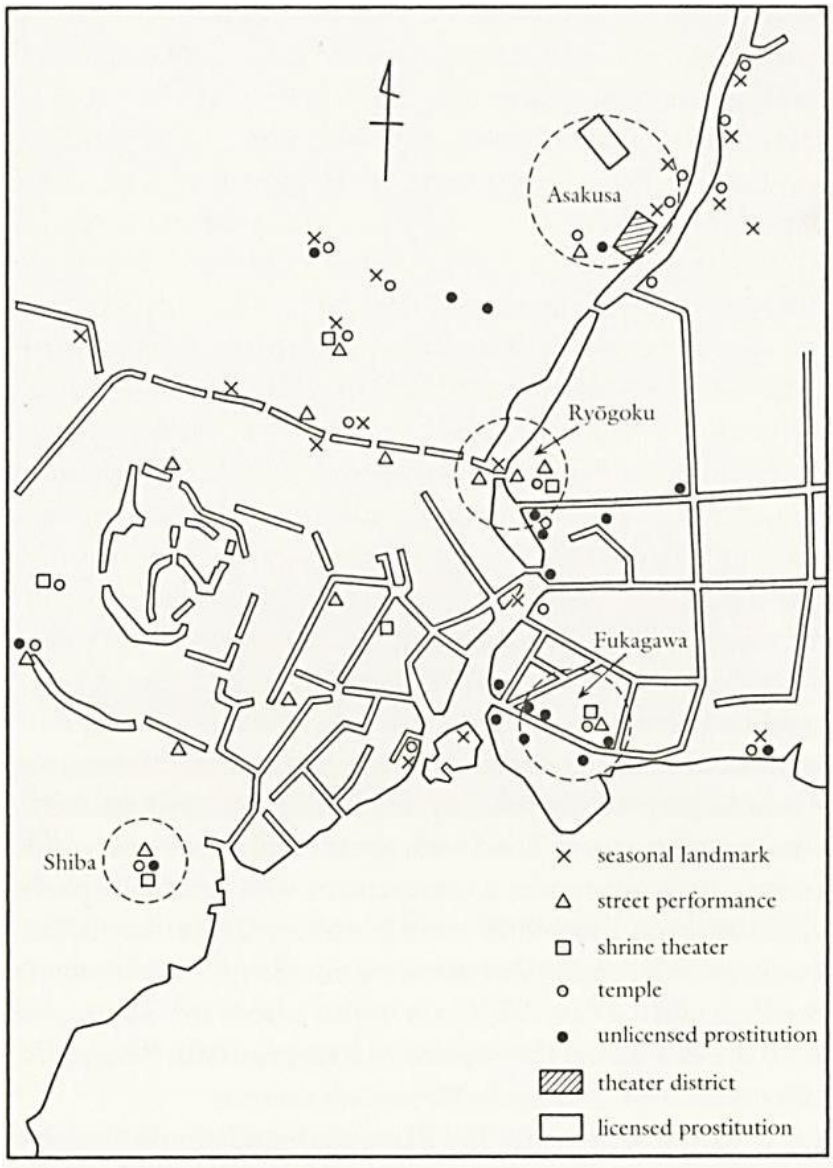

Fig. 7. 5 Amusement spaces in Edo in mid nineteenth century
Image Source: Jinnai Hidenobu, Tokyo: A Spatial Anthropology

However this urban boom was disrupted by the Great Meireki Fire of 1657. The fire started on 2nd March, 1657 and lasted for 3 days which destroyed 60-70% of Edo and claimed approximately 100,000 lives.

Several changes were made to Edo when it was re-built after the fire as listed below:

1. The high and the low cities merged.
2. Roads were widened and special attention given to the effective planning of the mercantile districts in order to boost the local and national economy.
3. Large open spaces were planned to work as fire breakers.
4. Several temples were relocated to the river banks since they were wooden structures and vulnerable to fires.

Despite the efforts of the shogunate, Edo deteriorated with occurrences of famine and fires and finally the end of the shogunate.

Meiji Period

The year 1868 marks the end of the Edo period and the beginning of the Meiji period. In this year, Edo was named Tokyo (eastern capital) as the Emperor Meiji shifted his residence from Kyoto to Tokyo and made it the official administrative capital of Japan. With the fall of the Tokugawa shogunate, a sea of change occurred as the feudal era ended and the modern era began.

1. Japan shed off its old feudal system and embraced a new "enlightened rule". The class biased laws of the Edo period were abolished and a new democratic system was introduced.
2. Modernization was the favourite catchphrase and westernization, the prevalent practice.
3. The numerous Daimyo residences that had housed the erstwhile ruling class were all vacant and so these large estates were adapted for the various public functions required in a modern capital city.
4. The older worn out structures were torn down and replaced by new buildings inspired by western architecture.
5. The face of Tokyo changed radically as architects borrowed grandiose features of classical European architecture and supplanted the traditional organic Japanese architecture with these sculptural facades.
6. The face of Tokyo was certainly different from Edo due to these changes however, since the development only replaced individual buildings, the city fabric including the roads and canals, was the same as that of Edo.
7. The industrial evolution of Japan took place during the Meiji Era.
8. The unification of the Yen occurred on May 10th, 1871.
9. The Meiji constitution was passed in 1889 which forms the basis of the current constitution adopted after World War II.
10. Trade with the US and UK and educational exchange with the west was started, stressing on Science, Technology and loyalty to the nation.
11. Westernization was also reflected in the adoption of western clothing, calendar and the metric system.

The wave of western style modernization changed the face of Tokyo. Although the urban fabric remained unchanged as previously mentioned, old wooden structures were replaced by brick and mortar building which stood in a haphazard heterogeneity with the traditional structures, especially of the residences of the city.

Taisho Period

The Taisho Era began in 1912 and saw an increasing number of people working in cities and leading consumer lifestyles. A marked improvement in literacy and gender equality was also emerging. In 1919, a new zoning law and designated building line law were passed (Okata, Murayama, 2011) to control the haphazard development of suburban areas, but this was largely a failure, producing areas of insufficient infrastructure and small scale, plot-by-plot development.

During the late Taisho period in 1923, Tokyo was destroyed by the Great Kanto Earthquake. Over 140,000 people were reported dead or missing, and 300,000 houses were destroyed (Fig 7.6).

Fig. 7. 6 A view of destruction in Tokyo, seen from the top of the Imperial Hotel, which was the only hotel in the region that survived the 1923 earthquake
Source: USGS/George A. Lang Collection accessed from "1923 Kanto Earthquake: Echoes from Japan's Past", The Atlantic, March 15th, 2011

Showa Period

The late Taisho and the early Showa period saw modernization on a more holistic level than that of the Meiji Era. Western ideas of city planning such as introduction of green belts were incorporated in the process of rebuilding the city of Tokyo after the devastation caused by the earthquake. The Edo fabric was partly altered as Japan's first subway line was opened between Asakusa and Ueno and the Haneda Airport and the Port of Tokyo were opened. By 1935 the resident population of Tokyo had grown to 6.36 million, comparable to the populations of New York and London.

However, Tokyo was once again devastated by the Pacific War which broke out in 1941 and led to the city being bombed 102 times causing the population of the city to be halved, to 3.49 million, by the time the war ended in 1945.

After the war in 1947, a new era of prosperity and change was seen in Tokyo. Notable events are:

1. The new Constitution of Japan and the Local Autonomy Law were passed.
2. The present day 23 special ward system was started in the Tokyo Metropolis in the same year.
3. This area saw huge economic growth in the 1960s due to technological innovations and industries. Mass production of synthetic fibres and electric appliances such as televisions, refrigerators and washing machines started during this time which brought about considerable lifestyle transformations.
4. The population of Tokyo crossed 10 million in 1962.
5. The Shinkansen was started and the Metropolitan expressway was opened in 1964, forming the foundation of Tokyo's current prosperity. The Olympic Games were held in the city in the same year.
6. Environmental issues of air, water and noise pollution were brought to the fore, accompanying the rapid industrialization and economic growth. This economic growth was halted in 1973 due to oil crisis.
7. In the 1980s, increasing Globalization and the emergence of the information society helped Tokyo achieve great economic success. Tokyo became one of the world's most active major cities, boasting attractions such as cutting-edge technology, information, culture, and fashion, as well as a high level of public safety. From 1986 onwards, land and stock prices spiralled upwards, a phenomenon known as the "bubble economy."
8. Tokyo became one of the preeminent Global cities of the world along with New York and London (Low, 1996: 393; Sassen, 2001: 215). The physical characteristics of the city became

increasingly westernized during this time and development was largely aimed towards providing affluent residential and commercial areas (Machimura, 1998). This caused social conflicts as the traditional Japanese way of life was gradually being replaced by an American consumer culture.

9. A culture of land re-adjustment has been practiced by the city's administration since this time, which converts "life space" to "economic space" (terms by Friedmann, 1988) under the pretext of Globalization. Traditional building regulations which stipulated that building intensity correspond to the street access were amended to keep up with global competition. The need to compete with Shanghai and Honk Kong was cited as a reason for flexible development regulations, more ad-hoc sale of FAR bonuses and greater subsidies for infrastructure improvements were introduced by the public sector to encourage the private sector to enter into such projects (Sorensen, 2000, 2005, pp. 234). As a result, inner city neighbourhoods have been redeveloped into high-rise towers since the 1970s, significantly reducing the quality of life and livability of these areas, as community ties are destroyed and life space is converted to economic space.

Heisei Period

The Heisei period started in 1989 and Tokyo thrived under the bubble economy. However, the bubble finally burst at the beginning of the 1990s. Although this was a major blow to Tokyo, the city has been able to spring back and overcome this financial crisis through two successive fiscal reconstruction programs.

7.1.2 Evolution of Economic Profile of Tokyo

The economic profile of Tokyo has changed from being a trade city, to an industrial city, to a post-industrial city, to a global city in the information age and an important nodal network city. During the Tokugawa rule, silk trade was an important function of the Tokyo harbour.

With the modernization of the Meiji era, the industrial revolution occurred in Japan. At this time many factories for weaving composite textiles and spinning raw silk were constructed and sold to well-connected entrepreneurs. Western technology was imported and production of items that could be sold to international markets was sought. Naturally, this era saw a tremendous growth in the number of works in the manufacturing industry.

Although the first half of the Taisho period saw major setbacks due to the Kanto Earthquake and World War I, Japan fought on the side of the victorious allies in the War and so was brought unprecedented prosperity in the post war era. Industrialization continued in this phase.

The beginning of the Showa period was affected by World War II, however, the post war period showed miraculous economic growth which made Japan the second largest economy in the world after USA. This is often called the "Japanese Post-War Economic Miracle" and occurred due to strong economic interventions by the Japanese government. A heavy industrialization policy was pursued encouraging the private sector to expand heavy industrial activities by providing a host of incentives such as huge loans and lenient repayment time frames. So, large scale chemical factories developed along Tokyo Bay and were major contributors to the economy. Also, interest rates were lowered for private tax payers to encourage spending. This was the time of the Japanese economic bubble so called because it depended on over-loaning to private conglomerates (often in amounts higher than their capital) by local banks, which in turn over-loaned from the Bank of Japan which in effect had complete control over the industrial activities. Trade liberalization was also pushed in this time, which made export a major contributor to the economy. This period of industrialization and rapid growth of GDP is often called the roaring 60s (1960s).

Of Tokyo's 5.6 million workers in 1970, 30.2% were in manufacturing, 26.3% were in wholesale and retail industries, 5.4% were in finance, insurance, and real estate industries and 21.3% were in service industries (Sassen, 2001). By 1980 the share in manufacturing had fallen drastically to 23.5% (Fig. 7.7).

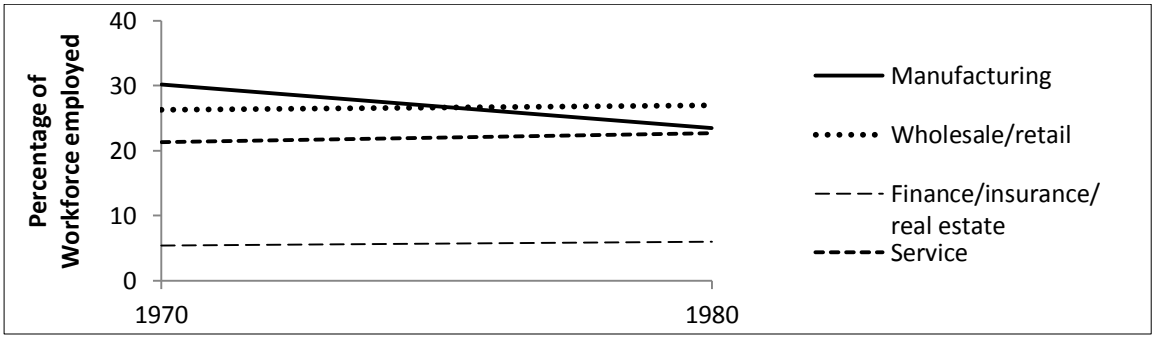

Fig. 7. 7 The shift from secondary to tertiary industry in Tokyo

The decline of the workforce in the manufacturing industry had two main reasons. Firstly, the growth in the tertiary sector attracted workers which reduced the share of workers in manufacturing industries. Secondly, the industrial units that had been constructed before Wold War II had been in the *shitamachi* area of the city which formed the industrial belt with many factories as well as workers' residences and was considered to be the outskirts of the city at the time. After World War II, as urban land values rose, the new industrial units were constructed further and further away from the city in areas such as Tama town and Yokohama city (*Ibid.*). These areas therefore attracted a lot of migration and became growth nodes which would

ultimately merge with Tokyo. This change in spatial location of industries also caused a fall in manufacturing industry within Tokyo city, which had increasingly become a hub of services.

The high growth years between 1985 and 1990 saw a sharp increase of 720,000 in the number of workers; in contrast, from 1990 to 1995 the number of workers rose by only 130,000. The occupations that showed growth in the 1990s were the professional, sales, services, and low-skill manual groups (Sassen, 2001: 244)

Tokyo's occupational structure showed a consistent increase from 1975 to 1995 of professional, both in actual numbers and in labour force share (Machiura, 1998), though at a declining growth rate. The highest growth rate of professionals was at 55% from 1975 to 1985, after which it fell to 17.5% from 1985 to 1990, and 8% from 1990 to 1995, when managerial and service jobs saw rapid increases. Manual labour saw the sharpest decline in numbers from 1975 to 1995 largely due to the decline in the manufacturing sector. The trend has continued with increasing foreign investments, Tokyo's workforce is focussed at providing services to cater to international businesses. The economy of the city cannot be seen in isolation as it is largely outside the control of the local administration and more under the influence of the global hierarchy of network cities. It is a major economic, information, and knowledge centre and a key node of the international economic machinery connecting the richest cities in the world.

7.2 A study of the issues in context of Tokyo – Forming new DM and DI datasets

At first, the analysis done in Mumbai and Ahmedabad was replicated using the DI and DM that had been applied to the previous case studies using data from the entire Tokyo Metropolitan Area. However, two very important issues came to light through the lack of any conclusive results of this analysis; firstly, the Tokyo Metropolitan Area consists of many cities, villages and islands with different density characteristics affecting human security in a variety of ways therefore, no clear relationship could emerge where so many different relationships exist. It was hence decided that the 23 Special Wards would be the focus owing to the urban characteristic of the area and comparable size and population with the other cities being studied. The second issue that came to light was that the DI datasets that had been used to gauge the Human Security of urban inhabitants in the Indian cases were not effective in Tokyo. This is due to the fact that Japan does not suffer from the lack of the most basic services required for human survival which debilitate the residents of Developing countries. However, this is not to say that Human Insecurity does not exist in Japan. As has been discussed in the first section, capability deprivation is very contextual and so, the insecurities of people must be measured using a suitable scale that will be able to gauge the specific insecurities of the people.

There was a need to look at the debilitating factors in a developed economic structure, rather than try to assess it using basic needs such as access to water, sanitation, education, etc., since all of the population will have access to such resources.

In order to understand the issues that might be plaguing the lives of the inhabitants of the 23 Special Wards of Tokyo, a study was done to understand the national concerns currently prevalent in Japan. This was thought to be a good reflection of the problems in Tokyo because over 90% of the population of Japan is urban and so the national problems will also be urban problems and prevalent in the largest urban area of the country.

Firstly, the 2013 United Nations' HDI report was studied and the HDI value and associated indices of Japan were compared to that of Norway, which has the best HDI ranking in the world, to see what makes Japan lag behind in terms of HDI (Table 7.1).

Secondly, the OECD better life index was studied and Japan was compared to the average values found among OECD countries (Table 7.2). The OECD; or "Organization for Economic Cooperation and Development" constitutes 34 member countries which are typically high-income economies with high HDI and most of them are regarded as developed countries. A comparison of the average presented by all of these countries therefore allows a comparison of Japan with its peers. This is hoped to help in gleaming the deprivations faced by the Japanese, when compared to other countries with similar resources.

Finally, the OECD economic survey for Japan was studied to see the time series changes that have taken place over the past decade (Fig. 7.8). This helped to understand and identify trends which may be causes for concern.

Table 7. 1 Comparison of HDI components of Japan with Norway

HDI component (2012 data)	**Norway**	**Japan**	**India**
Rank	1	10	136
Life expectancy at birth	81.3	83.6	65.8
Mean years of schooling	12.6	11.6	4.4
Combined gross enrolment in education	97%	89%	65%
Primary school dropout	0.5%	0.0%	34.2%
Income	48688	32545	3285
Inequality	0.894	-	0.392
Gender Inequality	0.065	0.131	0.610
Female/Male education	1.002	0.972	0.528
Fertility (births) per 1000 women aged 15-19	9	5	86.3
Female/Male labour force participation	0.880	0.689	0.359
Female/Male shares in parliament	0.657	0.155	0.123
Maternal Mortality	7	5	200
CO_2 emission per capita	10.5	9.5	1.5
% of population that is urban	79.7	91.9	31.6

The comparison of HDI components with Norway revealed that Japan had a lower average income. Additionally gender equity was very poor in terms of workforce participation as well as shares in parliament. Table 7.1 also shows the corresponding HDI components for India. India suffers a huge lag in nearly all of the components which further illustrates why the Development Indicators for India cannot be applied to Japanese cities. India is however nearly at par with Japan in terms of Female/Male shares in parliament, which exemplifies the very serious issue of the female population in Japan being highly discriminated against in terms of parliamentary participation in spite of having equal access to education and a seemingly egalitarian society.

The OECD better life study showed unaffordable housing, gender inequality in employment, insufficient social cohesion were the factors in which Japan fell short of the average value of all OECD countries.

Table 7. 2 Comparison of OECD Better Life Index average values of all OECD nations with Japan's national figures

OECD Better Life index		**Japan**	**OECD Average**
Housing	Expenditure on housing	22	21
	Housing Satisfaction	77	87
	Dwellings with basic facilities	93.6	97.8
Income	Household net adjusted disposable income	24147	23047
	Household financial wealth (USD)	74966	40516
Jobs	Employment rate	70	66
	Gender inequality in employment	20	12
Community	Social interaction	25	48
Education	Educational attainment %	92	74
	Student skills %	529	427
Environment	Water quality	86	84
	Air pollution	24.9	20.9
Civic Engagement	Trust on political institution	53	56
	Voter turnout	69	72
Health	Life expectancy	83	80
	Regular smokers	19.5	21.1
	Obesity	3.5	17.8
	Self-reported health %	30	69
Life satisfaction	Satisfaction	6	6.6
	Daily positive experiences	87	80
Safety	% victim to assault	1.4	4
	Homicide rate	0.4	2.2
Work - life balance	Work hours per year	1728	1776
	Personal time	14	14.9

A study of the time series data between 2004 and 2011 given in the OECD Economic Survey of Japan 2013 revealed that the GDP has been dropping since 2010, government debt

increasing since 2007, unemployment has been increasing since 2009, the population growth rate has dropped since 2010, the youth population has been dropping since 2004 and elderly population increasing gradually since 2004. The country already in recession was then hit by tremendous natural disasters which deepened it recessive economy. Many people have been put out of job due to the dwindling economy. Population growth rate is decreasing with an ever decreasing number of youths joining the work force (under 15 population) and an ever increasing retired population (over 65 population) the labour force is shrinking further hence causing even more cause for concern for the economy in the future. Huge economic stimulus packages and aggressive trade policies are being carried out at the national scale. Even if these are successful in reviving the economy, it will take time and in the meantime, economic insecurity in urban areas is an issue.

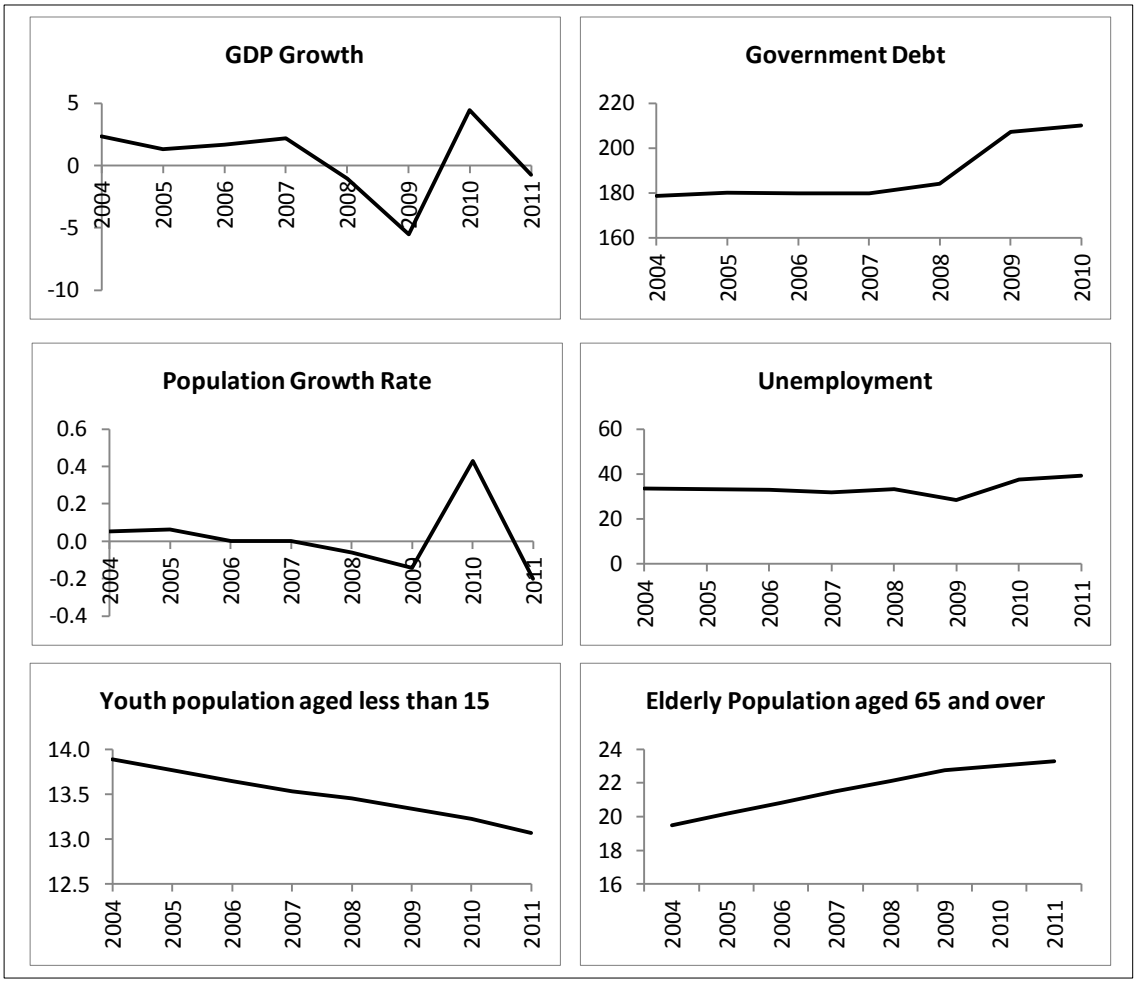

Fig. 7. 8 Results from OECD Economic Survey of Japan, 2013

The final issues that arise from the study of all the three reports are, sinking economy, housing unaffordability, ageing society and gender inequality. The human security of Tokyo

must therefore be decided by the deprivation caused by these issues and the DI used for the statistical analysis of Tokyo must therefore quantify them. The quantitative measurements of these issues are presented in Table 7.3.

7.3 Statistical Analysis of Tokyo

7.3.1 DM and DI of Tokyo

Consequently, the issues identified that need to be quantified in the DI for Tokyo were, affordability of housing, measure of the inverted age pyramid, gender inequality in employment, and environmental degradation. Additionally, DI datasets of Health and Education were discarded as no inter - ward inequality could be found as everyone had access to these amenities. Furthermore, the DM datasets corresponding to amenity were altered to measure the amenities that might not be available to all parts of the population. The final datasets used to quantitatively compute the DI and DM of Tokyo's 23 Special Wards are shown in Table 7.3.

Table 7. 3 DI and DM with corresponding datasets and data sources for Tokyo

		Dataset	Data Source
DEVELOPMENT INDICATORS			
1	Economic Equity	% Unemployment	Tokyo Statistical Handbook 2005
		% of ward households assisted by district	
2	Social Equity	% of females in total employed persons	
		Senior citizen population / working population	
3	Governance	Crimes reported / ward population	
4	Environment	Complaints of Air Pollution	
		Complaints of Noise Pollution	
DENSITY MEASURES			
1	Physical Density	Person/ sq.km	Tokyo Statistical Handbook 2005
		Households/ sq.km	
2	Intensity	Gross built density per Ha	
		Net construction density	
3	Amenity	% of mixed land use / sq.km	
4	Autonomy (Job Density)	% of workforce in main employment in ward by average of city	
5	Frequency	Difference of daytime density and nigh time density	

7.3.2 Exploratory Analysis of Relationships between DM and DI

Scatter plots comparing each DI and DM were created similar to the other case studies. Economic, Governance, and Environment datasets of DI showed a strong linear relationship with the DM. The Pearson's correlation coefficients between each of the DI and DM were also found as shown in Table 7.4.

Table 7. 4 Correlation Analysis for DI and DM of Tokyo

	Physical	Intensity	Amenity	Autonomy	Frequency
Economic Equity	-.319	-.598	-.177	.903	.453
Social Equity	-.098	-.264	.137	.615	.409
Good Governance	.581	.343	-.418	-.473	-.878
Environment	.588	.351	-.255	-.509	-.755

Correlation is significant at the 0.05 level (2-tailed).

Correlation is significant at the 0.01 level (2-tailed).

7.3.3 Multiple Regression Analysis of Tokyo Data

The composite DI was calculated using data corresponding to Economic Equity, Social Equity, Governance and Environment. This was taken as the dependent variable of the regression analysis and Physical Density, Intensity Density, Amenity Density, Autonomy Density and Frequency Density were taken as the independent variables. The adjusted R^2 of the first regression model was 0.462 (Table 7.5) which had low sig. values for all of the independent variables except for Amenity (Table 7.6). Amenity was therefore excluded from the second regression model which had a resulting adjusted R^2 value of 0.487 which was better than the previous model. The sig. values were also lower than the previous regression model. The expected and observed residuals were plotted which showed very little deviation and no outliers (Fig. 7.9). This regression model was used to predict the values of DI across the 23 wards of Tokyo (Fig. 7.10).

Table 7. 5 Model Summary of Regression Analysis for Tokyo

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.764	.584	.462	.08682
2	.762	.580	.487	.08473

Table 7. 6 Regression co-efficients for Tokyo

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.507	.089		5.719	.000
	Physical	.329	.143	.635	2.304	.034
	Intensity	-.246	.166	-.473	-1.483	.156
	Amenity	-.040	.105	.093	.378	.710
	Autonomy	.287	.098	.630	2.929	.009
	Frequency	-.257	.117	-.584	-2.197	.042
2	(Constant)	.506	.087		5.853	.000
	Physical	.315	.134	.607	2.344	.031
	Intensity	-.208	.128	-.399	-1.623	.122
	Autonomy	.286	.096	.629	2.998	.008
	Frequency	-.233	.096	-.530	-2.434	.026

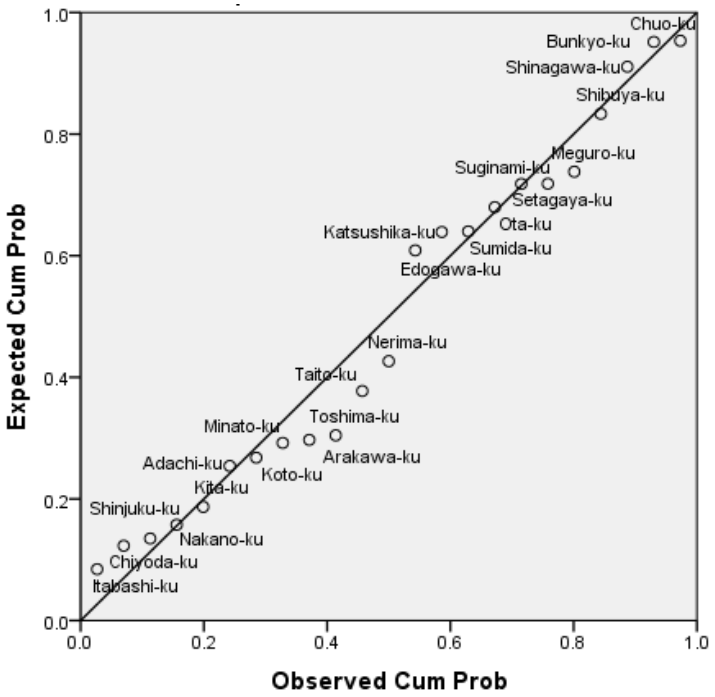

Fig. 7. 9 Normal P-P Plot of Regression Standardized Residuals for Tokyo

The regression equation found was:

$$DI = 0.506 + 0.315\ Physical\ Density - 0.208\ Intensity + 0.286\ Autonomy - 0.233\ Frequency$$

Equation 7. 1 Regression Equation for Tokyo

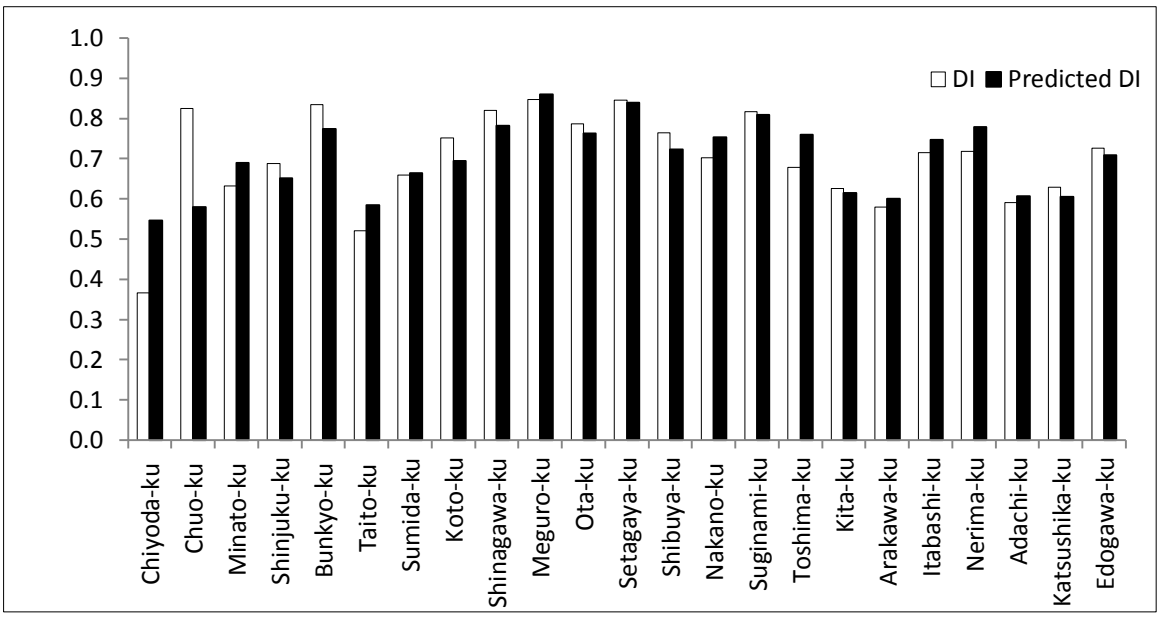

Fig. 7. 10 Plot of Actual DI and Predicted DI by regression equation for Tokyo

7.3.4 Cluster Analysis using DI

As in the previous cases, the clustering was done using the Ward's minimum variance method of hierarchical cluster analysis using squared Euclidean distance as the interval measure and composite DI as the clustering criteria. The results of the cluster analysis are shown in Fig. 7.11. Fig. 7.12 is a plot showing the distribution of wards in each cluster, which shows that in Tokyo, the majority of the wards belong in the high DI clusters, with 22 out of 23 wards having DI above 0.5 and 16 out of 23 wards belonging in clusters of average DI or higher.

Fig. 7. 11 Cluster Analysis of Tokyo using Ward's Minimum Variance Method

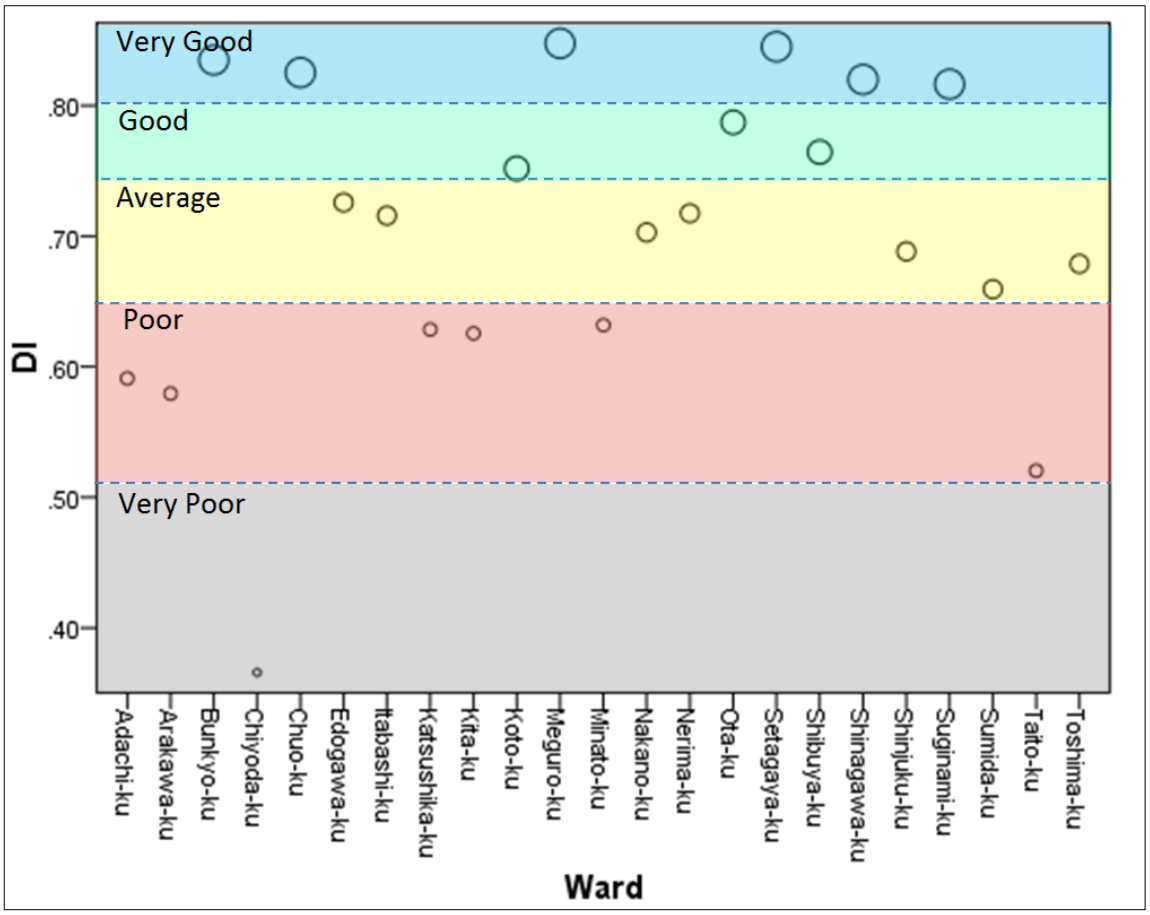

Fig. 7. 12 Distribution of Tokyo's wards among the 5 DI clusters

The cluster analysis revealed Chiyoda ward to have the worst human security. This attracted further investigation because this ward is known to house the Imperial Palace, various foreign embassies and on the whole have a good environment. However, closer investigation revealed that this ward has the highest levels of crimes reported and very high air and noise pollution levels. However it does not follow the trends of increasing percentage of assisted households, decreasing female employment and increasing senior citizen dependency, which are apparent in the trends of decreasing DI. Additionally, the factor which make it an area of very poor human security; crime and pollutions, are seen to be uniform in all the other clusters. It is therefore understood that this area has its own individual issues not prevalent in the rest of the city and if these issues had not been considered, then it would have shown to have a good human security following the overall trends. Furthermore, it was understood that the north-east corner of the ward, namely the Akihabara Electric Town area was the major problem area of the ward and it was due to the high crime rate and pollution of this zone that the entire ward was shown to have very poor human security.

Additionally, this ward on the whole had drastically low population density and built density as compared to the rest of Tokyo and extremely high daily floating density. However, it

is possible that the floating density may be concentrated in only certain pockets of the ward and also, this ward may have high residential density in certain parts and be very sparsely populated in large areas bringing down the overall density. These local density characteristics may give better explanations for the occurrences of crime and pollution.

7.3.5 Inter-cluster variation of DI datasets

The cluster-wise means of DI datasets which had Pearson's correlation coefficient greater than 0.5 with the cluster means of DI values, were plotted as shown in Fig. 7.13. It is clear from this figure that **areas of high number of assisted households, low female employment and high number of senior citizens have a lower human security**. It was however noticed that the worst cluster which was Chiyoda, did not adhere to any of these trends, yet it was designated as the ward with worst DI. The reason for this becomes clear after looking at the data for crime and population. Although crime and population do not follow any significant trends across all the other clusters and seem to be quite uniform in all the other wards, these are particularly high in Chiyoda. The difference between the number of reported crime in Chiyoda and the amount of noise and air pollution in Chiyoda is so much higher than the rest of the city that Chiyoda gets the lowest DI based on just these two measures.

Chiyoda is one of the most important wards of Tokyo and the high level of crime and pollution reported, called for further investigation. Documents such as news articles revealed that while the greater part of the ward is crime-free, the north-eastern corner of the ward, namely the Akihabara area, has a very high number of reported crime incidents and it is here that the air and noise pollution levels are also very high. It is therefore fair to assume, that if Chiyoda was analysed in two parts i.e., Akihabara and the rest, and the cluster analysis done, then Akihabara would be in the "red" zone with the other northern wards whereas the rest of Chiyoda would be in the "blue" zone (Fig. 7.14). However, in the absence of such area – wise data, this can only be an assumption.

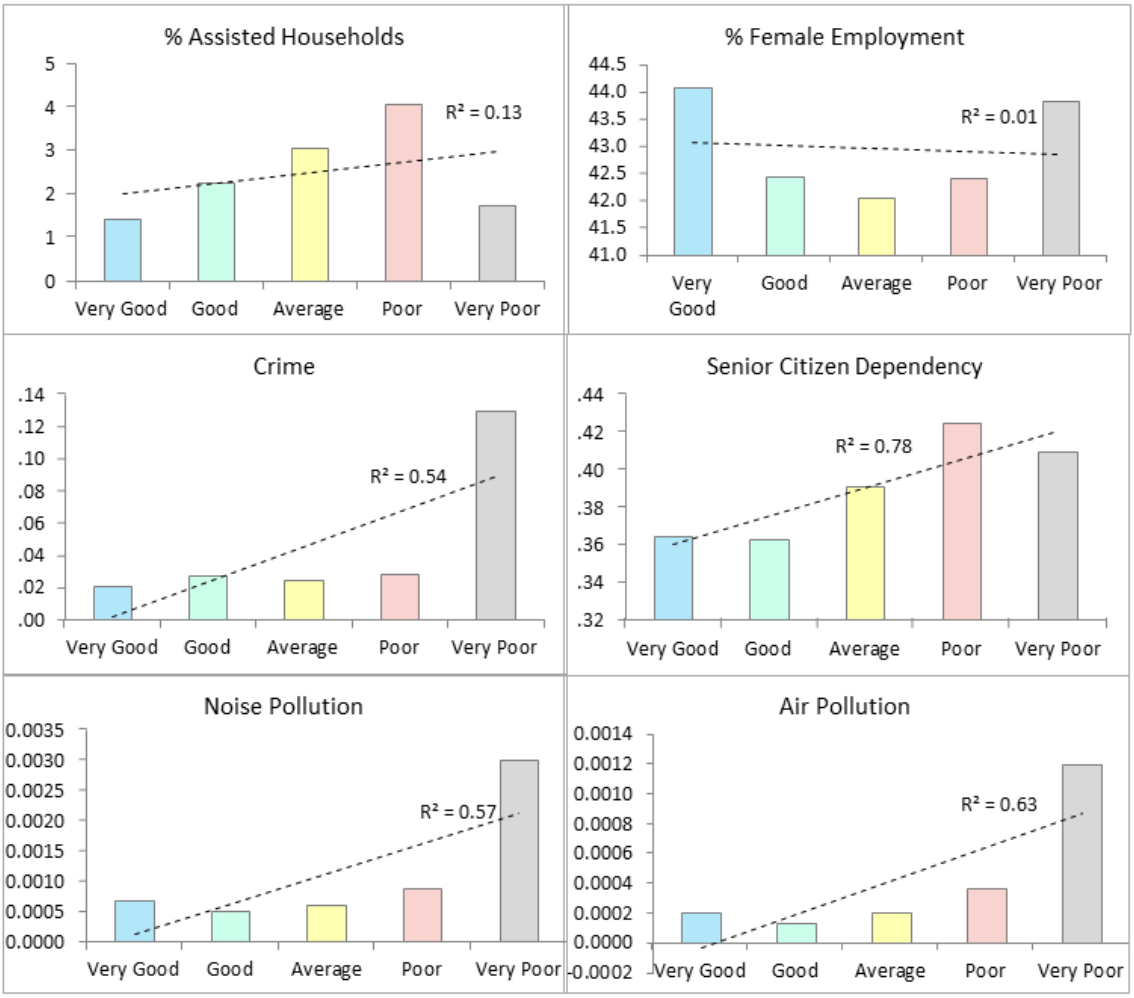

Fig. 7. 13 Cluster wise mean variation in DI datasets for Tokyo

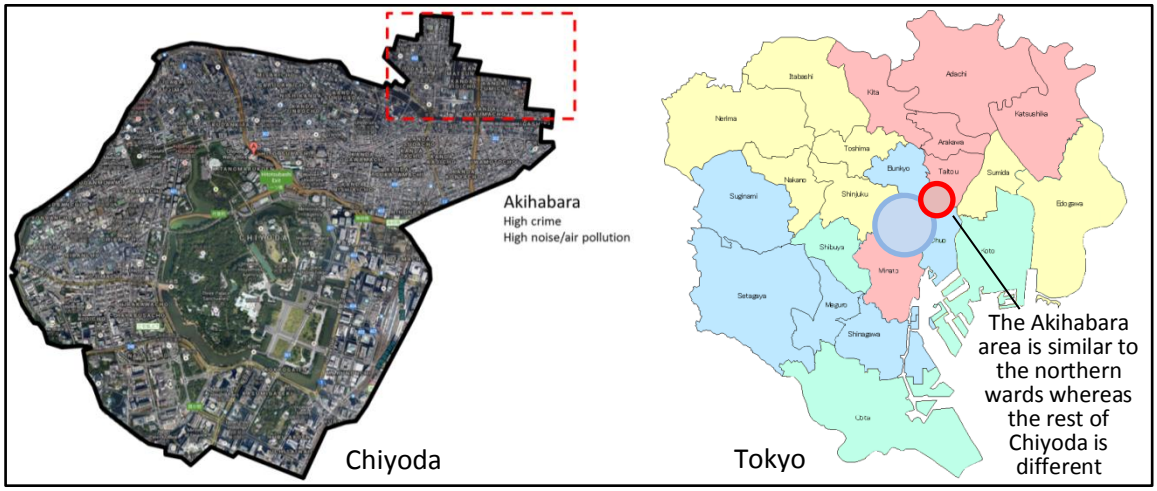

Fig. 7. 14 Spatial variations in DI in Chiyoda

7.3.6 Variations in DM datasets corresponding to DI clusters

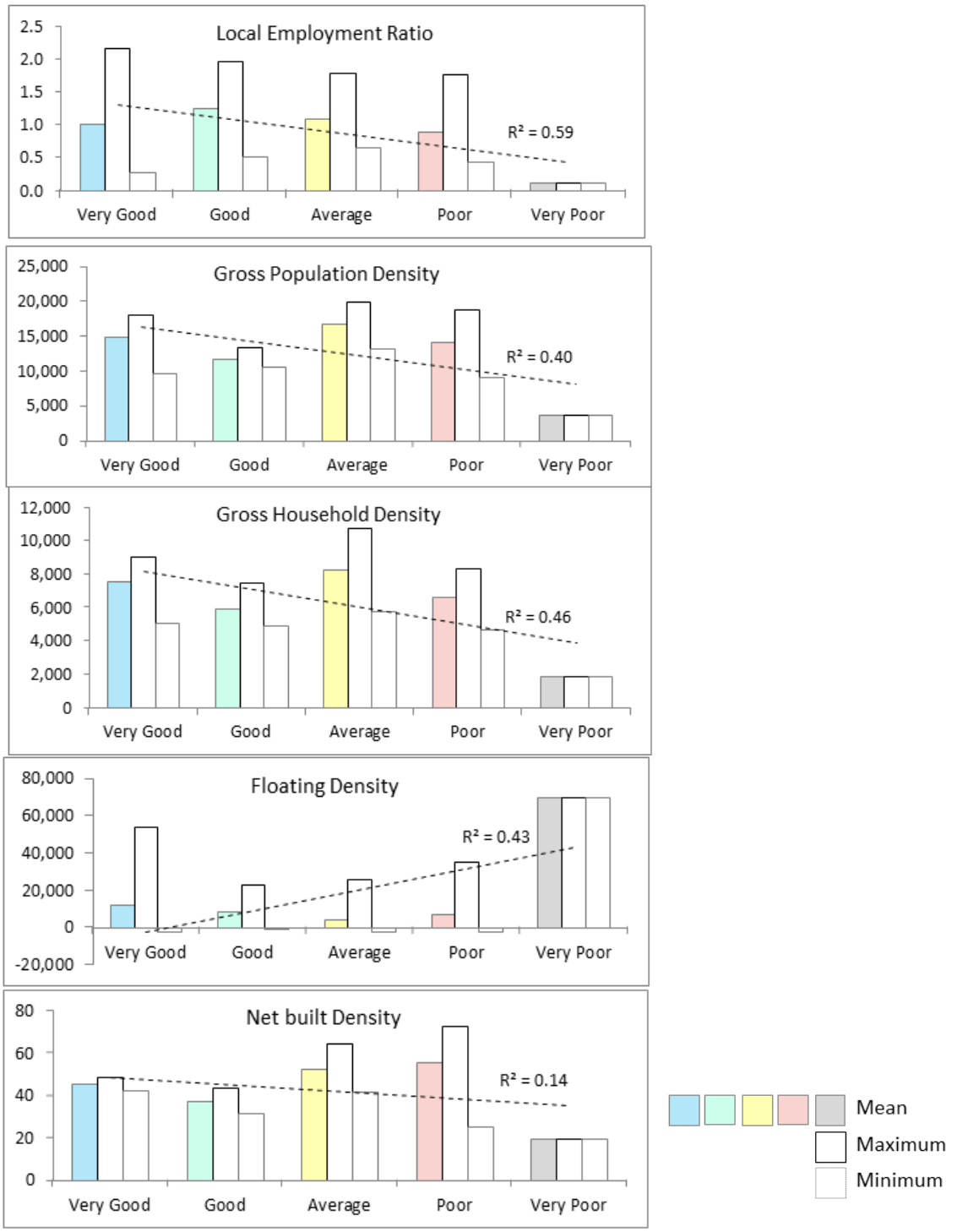

Fig. 7. 15 Cluster wise mean variation in DM datasets for Tokyo

From the plot of cluster-wise mean values of DM datasets it can be said that the datasets corresponding to employment play the largest role in predicting the trend of DI across clusters. The average value of "Net built density" also increased from the Good DI cluster to Average, to Poor DI cluster, which supports the negative term associated with intensity in the regression

equation. In Tokyo, leaving aside the very high DI cluster and very poor DI cluster, the DI in the mid-range clusters shows a negative linear relationship with intensity. This suggests that intensity may have a negative effect on DI by causing a reduction in urban breathing spaces, in wards where other factors of stronger influence on DI are absent (such as high female employment and high crime or pollution).

7.4 Discussion

The results of the statistical analysis prove that a relationship between DM and DI does exist in the wards of Tokyo, for data from 2005. The regression equation for this relationship is:

$$DI = 0.506 + 0.315\ Physical\ Density - 0.208\ Intensity + 0.286\ Autonomy - 0.233\ Frequency$$

Additionally, the cluster analysis showed that the ward of lowest DI; Chiyoda had a high crime rate and population. On closer study, it was understood that only a part of the ward exhibited these characteristics whereas the rest of the ward had high human security levels.

There was a very clear spatial differentiation of DI levels across the wards. The northern wards including the northern part of Chiyoda had lower values of DI. The southern wards had high values of DI, with Minato being the only exception to this rule. It is interesting to note that these results are concurrent with the Social Areas of Tokyo identified in the book by the same name, which states that the northern wards are the residential areas of blue collar workers and the southern wards the residential areas of white collar workers as shown in Fig. 7.16. Minato is stated to be a ward of heavy industrial areas in the same study. It can therefore be concluded that the DI framed for Tokyo are successful in the quantitative measurement of the human security of the wards' inhabitants. Furthermore, an equation which can predict the human security based on layers of urban density has also been formulated.

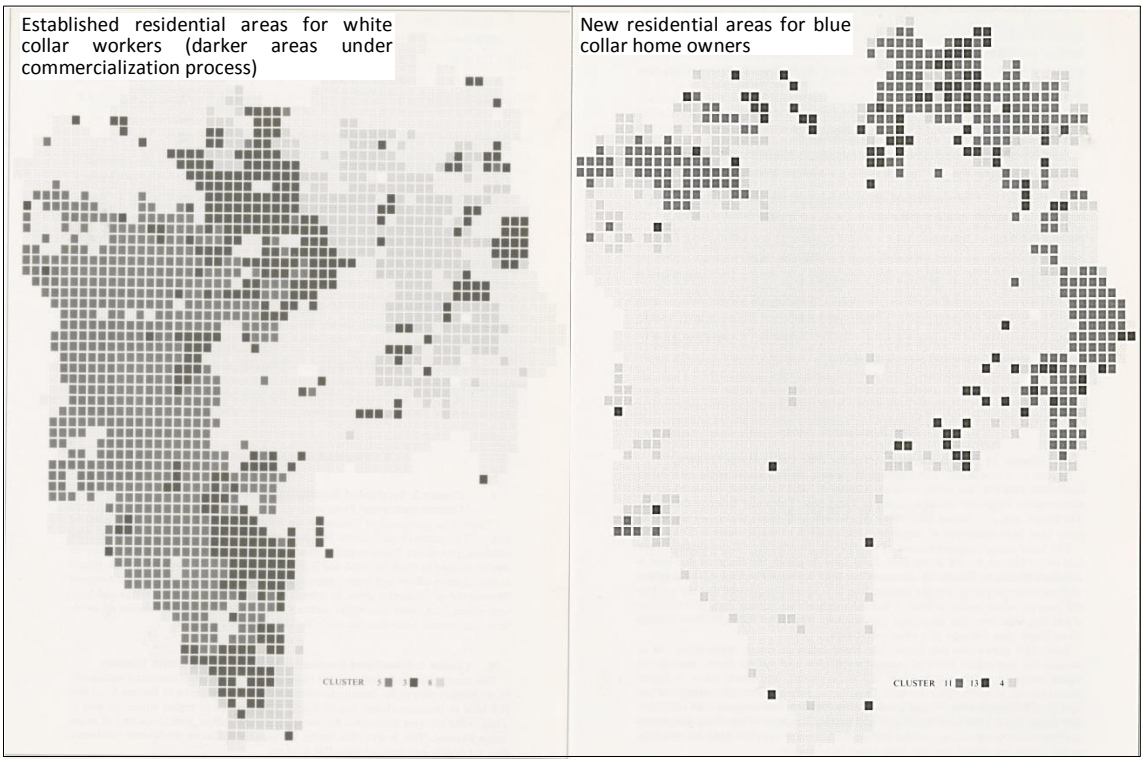

Fig. 7. 16 Residential Classifications in Social Areas of Tokyo
Image Source: Kurasawa, S. (Ed.). (1986). Social atlas of Tokyo. University of Tokyo Press, pp.293, 297

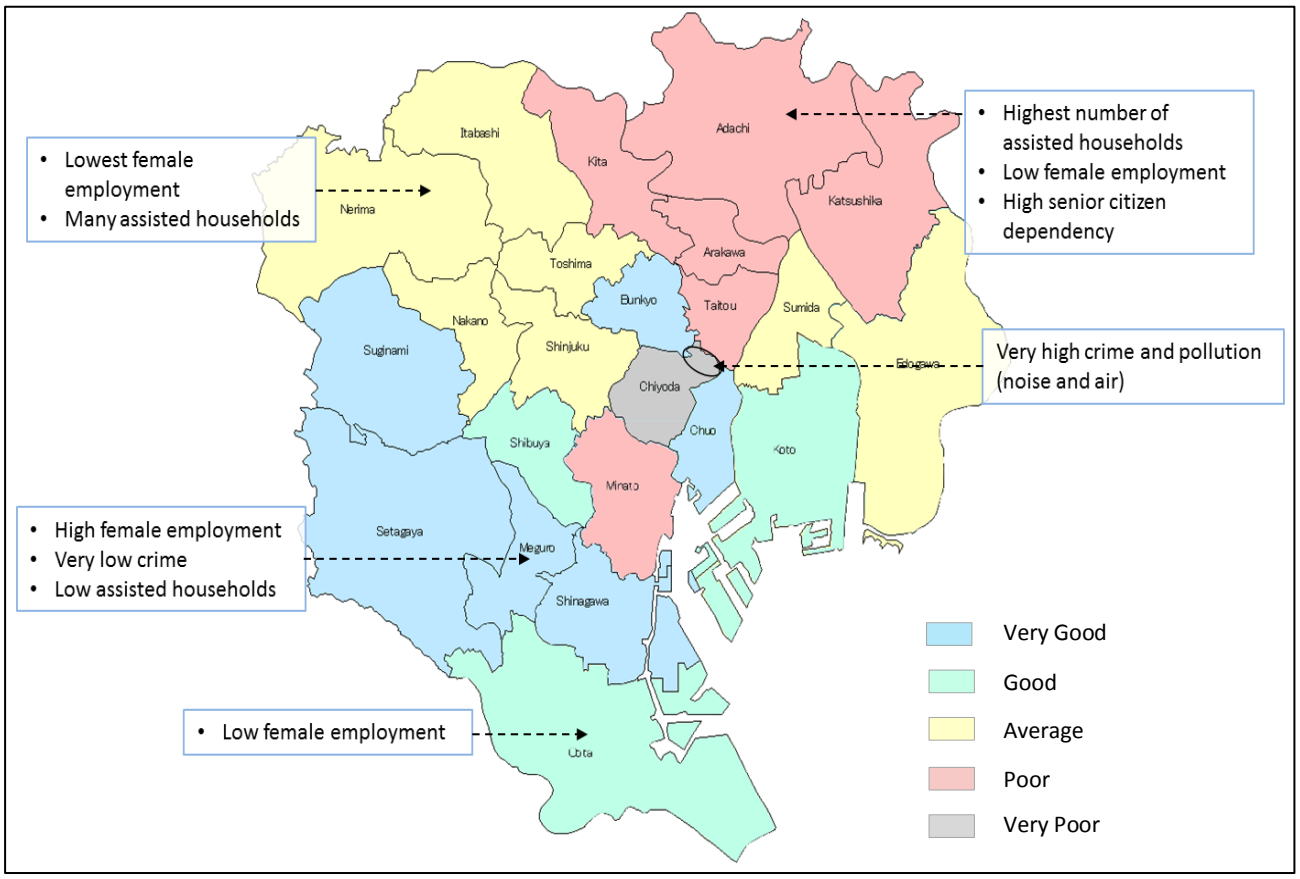

Fig. 7. 17 Cluster characteristics in Tokyo

7.4.1 Land Readjustment for increasing Built Intensity

High Intensity was found to be a major factor associated with lower DI in the clusters of Tokyo as discussed in section 5.2.6. The reason behind the high built density, small average plot size and higher building heights (in relation to plot sizes) was investigated and an explanation was found in the urban planning practice of "Land Readjustment" that was used to restructure and modernize the city.

Land readjustment is a method by which the ownership of scattered and irregular plots is pooled, a part of which is used to construct city serving facilities such as roads and other infrastructure, and then the remaining land is subdivided into regular plots and handed over to the original owners. Typically, each landowner contributes about 30% of their previous land holding to provide space for roads, parks, other public space and for reserve urban land. The reserve land is sold by the public authority to fund the planning and construction of the infrastructure projects. The landowners' gain comes from the increased value of the land facilitated by better connectivity and higher level of amenities, even though the size of the remaining area is smaller.

Although the practice of land readjustment had existed since the Meiji restoration, it was popularized and expanded to large scale urban rebuilding projects after the Great Kanto Earthquake of 1923. At this time, land readjustment was used to rebuild large areas of downtown Tokyo and Yokohama. A special agency was set up to carry out these works. It was also widely used in the 1930s to construct military facilities and in the aftermath of World War II for urban reconstruction of Tokyo which had been severely damaged by the war (Sorensen, 2000).

The practice of land readjustment allowed people to retain the sites they originally occupied, with enhancement in their quality and value. The city administration employed this technique to upgrade city infrastructure to serve the growing city and increasing population, and to keep up with the modern urban amenities in western developed countries. However it was not used to regulate the built space. Therefore, land readjustment, while focussing on building new thoroughfares, often gave rise to reduced building sites, produced irregular and often tiny lots and pushed buildings further up in height (Hein, 2010).

Although high net built density which has been brought about by land readjustment has been shown to have a negative linear relationship with DI in some of the DI clusters, this trend is not followed by the best DI and worst DI clusters. Additionally, even in the clusters in which this trend is observed, there is a large deviation from the mean shown by many of the wards. Therefore, it cannot be claimed to be a crowding factor and cause for lower DI levels. There are

in fact many merits of this technique which might lend itself to be a useful planning tool in urban areas of developing countries. Some of these merits are explained below:

1. Land readjustment has the potential to be "self-financing" for urban land and infrastructure development projects, as a part of the original plots is appropriated by the planning authority, which sells it to fund the project cost.
2. The original land owners retain title to the majority of the land which results in less opposition to the projects and less disruptive to the original community.

This is quite similar to the mechanism used by the Slum Rehabilitation Scheme employed in Mumbai, discussed in chapter 5, section 5.3.1. Although it does definitely provide a financial benefit, the case study in Mumbai has shown how the lack of control on maximum built density can cause this to be misused in favour of the private sector, and be damaging to the original residents particularly in slum rehabilitation where land ownership rights are controversial and livelihoods are destroyed in the readjustment process.

Land readjustment continues to be a favoured mode of development in the city with major projects in 10 districts currently underway (Urban Development in Tokyo, 2011, p.8). These range from new comprehensive development projects, to redevelopment of built-up areas, to waterfront development, expansion of station facilities, as well as projects for disaster preparedness and fire safety. There are also major road construction activities currently underway in an effort to efficiently connect the ward areas to the metropolitan areas through a series of rings.

7.5 Conclusion

An investigation of the relationship between DI and DM has been carried out in Tokyo using the same methodology previously applied to Mumbai and Ahmedabad. As with the previous cases, several objectives of this research have been achieved in this chapter. These are explained below:

1. The DM and DI have been adapted for the case of Tokyo, with several major changes to the DI in recognition of the fact that human security is relative and will differ greatly from a developing country to a developed country. Measures which are capable of identifying comparative low security areas in Tokyo have been proposed. The DI and DM have been calculated using secondary data, hence achieving the third objective of the research.
2. The wards of poor human security have been identified and the DI characteristics defining these poor human security levels have been found to be **areas of high number of assisted households, low female employment, high number of senior citizens, high levels of crime,**

and noise and air pollution. The DM characteristics corresponding to low DI areas are, **low autonomy, low residential density and high built intensity areas.** Areas of low residential density and high intensity are generally areas with predominantly office or retail establishments, with very high daytime density and very low night time density. These areas do not have the security brought about by resident communities with "many eyes on the street" as discussed at length in many of Jane Jacob's works and are therefore areas where **crime levels are high**.

3. The results of the regression analysis and cluster analysis in Tokyo indicate that areas of high residential and amenity, with low intensity and frequency, correspond to high DI areas. In other words, **areas where a large number of people live and work and where there are many open spaces and less floating population density are favourable density conditions for high DI**. The opposite of these density conditions may intensify the existing socio-economic insecurities of the area.
4. High cost of housing is a major problem in Tokyo which has forced a majority of the working population to find residences at very far distances from their working places within the city. This has caused the floating population of the city to be very high. Also, the high land price has caused high intensity development and the depletion of open areas. Following the land rent theory, commercial and office uses occupy the central city, with very low residential density, high floating daytime density and high building intensity, which lead to high pollution during office hours and high crime after office hours. The high intensity and low physical density is a result of the neo-liberal development policies introduced in the 1980s. (Sorensen, 2005). The areas which have high residential density with sufficient employment in the vicinity do not suffer from the aforementioned problems and are therefore the areas of high DI.
5. It can therefore be concluded that **increasing the occupancy, number of floors, and mixed use nature** of the low DI areas is **a necessary first step** for sustainable development. This must then be followed up by **actions to improve the inclusion of senior citizens in local community, encourage female employment, and increase number of semi-skilled jobs** so as to employ larger masses and reduce the number of assisted households. A large number of assisted households consist of senior citizens and for whom community engagement can be a stronger tool than just financial assistance.

7.6 Way Forward

7.6.1 Need for forecasting and modelling of Density Measures

A relationship between the DM and DI has been found in this analysis using the data of 2005. The DMs which show relationships with the DI follow the same trend over all the wards. It is therefore plausible to consider that future levels of DM can be modelled using a function related to the future distribution of DI levels in the city wards. Modelling the DM can help to identify areas where DMs need to be changed before changes in DI can be attempted.

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Chapter 8:

MICRO - LEVEL MESH ANALYSIS, MODELLING URBAN DENSITY AND APPLICATION OF METHODOLOGY

"My analysis stands by itself. This is our world, the world of the Information age. And this is my analysis of this world, which must be understood, used, judged, by itself, by its capacity, and incapacity, to identify and explain the phenomena that we observe and experience, regardless of its newness."

- *Manuel Castells, 2010*

The previous chapters have established the necessity to identify the factors in each urban area that are highest in demand, or crowded to the greatest extent, and understand how this crowding affects the physical, social, and environmental security of individuals of various socio-economic classes of the city. This understanding will then allow for a more targeted approach where funds can be more effectively applied to specifically bridge the gaps between the various socio-economic groups, so as to bring about a more equitable urbanization process.

This chapter discusses a "macro to micro" approach in investigating the relationship between the DM and DI. A summary of the findings of the macro level analysis are presented and a discussion on intercity observations follows. The need for micro-level analysis has been identified in chapters 5 and 6 at the ends of which it was proposed as the next step in the research. This is further illustrated through the intercity comparison of built intensity characteristics in this chapter. A range of urban typologies are identified through the micro-level analysis illustrated for Mumbai, in an attempt to identify socio-economic insecurities through physical density characteristics. An attempt to model DM based on DI has been made in the final part of this chapter using adaptations of traditional urban density functions.

8.1 Discussion of the Macro level Statistical Analyses

The macro analysis, the methodology of which was discussed in chapter 4 and applied to the study areas in chapters 5, 6 and 7 are discussed in brief. At first, Pearson's correlation co-efficient was calculated and scatter graphs plotted to observe any apparent trend in the data. Next, a multiple linear regression analysis was done to find the extent to which each of the DM effect the DI in a linear relationship (Table 8.1).

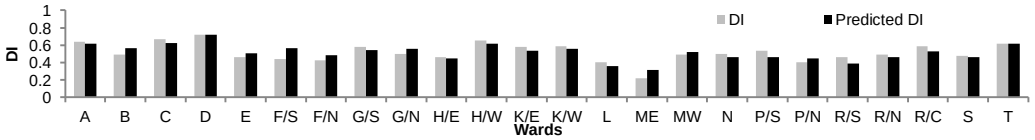
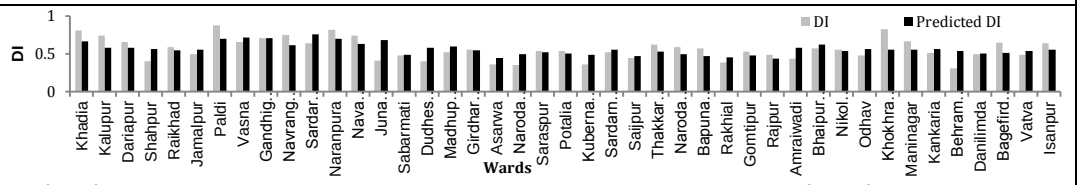
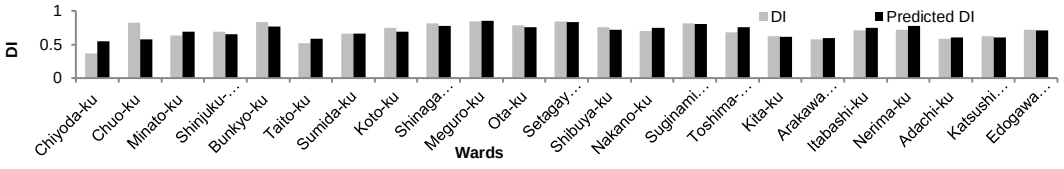
The cluster analysis was done using the Ward's minimum variance method of hierarchical cluster analysis using squared Euclidean distance as the interval measure and composite DI as the clustering criteria. The wards were therefore grouped into clusters based on the proximity of their composite DI to other wards of similar composite DI. Separate clusters are therefore far away in the context of their DI score and consequently reflect the inter-ward gaps present within the cities (Fig. 8.1).

In Mumbai, the best DI wards are in the south where the old CBD is located and in the west where the new business zone has been developed. Areas of good human security surround these wards. The railway line has long stretches of slums which is probably the reason for the low DI wards along the railway line, in the heart of the city. The worst DI ward is ward M/E. In Ahmedabad, a very clear spatial separation of high and low DI ward clusters was seen on the western and eastern banks of the Sabarmati River. The worst DI clusters corresponded

to the old industrial areas of the city. The eastern part of Ahmedabad is the older part which has grown over many phases of changing economic functions. The western part is the newer and well planned area which houses major educational institutes, health facilities, and affordable residential areas for all economic classes.

The cluster analysis in Tokyo revealed Chiyoda ward to have the worst human security. Investigation revealed that this ward has the highest levels of crimes reported and very high air and noise pollution levels. The cluster analysis also showed a very clear spatial differentiation of DI levels across the wards. The northern wards had lower values and southern wards had high values of DI, with Minato being the only exception to this rule. It is interesting to note that these results are concurrent with the spatial pattern found through multi-layered clustering of mesh data in Social Atlas of Tokyo (Kurasawa, 1986).

Table 8. 1 Results of regression analysis in Study Areas

City	Adj R^2	Plot of DI (actual values of each ward) and Predicted DI (calculated using regression equation) and Regression Equation
Mumbai	68.8%	 Predicted DI = 0.239 + 0.403 Amenity + 0.383 Autonomy + 0.166 Frequency – 0.314 Physical Density
Ahmedabad	30.8%	 Predicted DI = 0 .474 + 0.286Autonomy Density + 0.062 Amenity Density – 0.071 Physical Density
Tokyo	48.7%	 Predicted DI = 0.506 + 0.315 Physical Density – 0.208 Intensity + 0.286 Autonomy – 0.233 Frequency

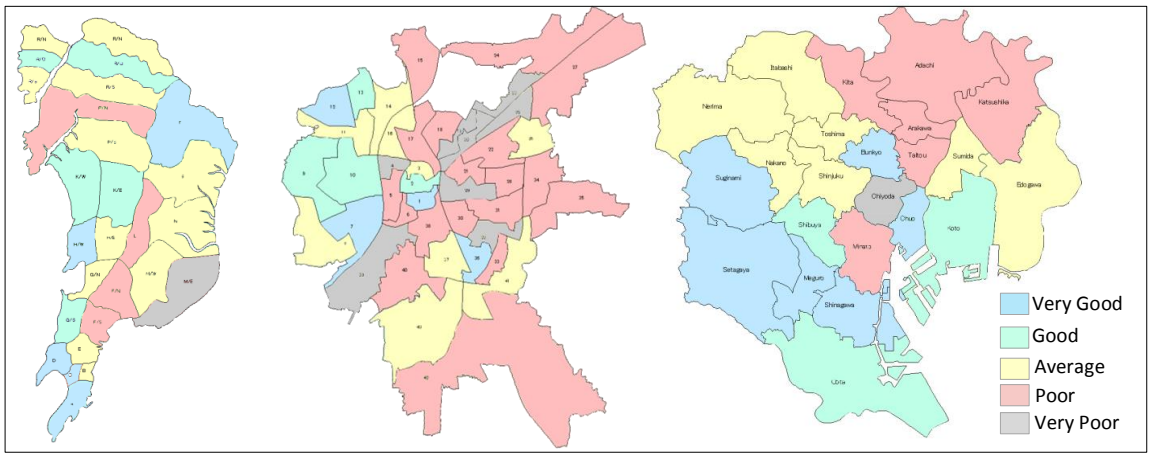


Fig. 8. 1 Cluster Analysis Results of Mumbai, Ahmedabad and Tokyo

A close observation of average datasets representative of each cluster was done, to ascertain the factors that are most closely related to levels of human security (Table 8.2).

Table 8. 2 Cluster averages of highly correlated DI and DM datasets

	Cluster 1			Cluster 2			Cluster 3			Cluster 4			Cluster 5		
	Mum	Ahm	Tok	Mum	Ahm	Tok	Mum	Ahm	Tok	Mum	Ahm	Tok	Mum	Ahm	Tok
DM	**0.66**	**0.84**	**0.83**	**0.58**	**0.74**	**0.77**	**0.49**	**0.65**	**0.7**	**0.42**	**0.53**	**0.6**	**0.22**	**0.39**	**37**
Sewerage %	84.75	103.7	100	75.83	112.2	100	66.58	99.71	100	59.37	92.28	100	37	95.3	100
Water Supply %	93.82	94.75	100	95.8	96	100	94.48	92.71	100	92.07	92.28	100	84.88	92.3	100
Local Employment Ratio	2.16	1.06	1.01	1.33	1.04	1.25	1.16	1.02	1.1	1.43	0.98	0.89	0.7	0.98	0.12
Gross Population Density (p/sq.km)	48407	26924	14948	35152	23613	11769	31640	30561	16649	40930	28274	14046	19834	33174	3589
Gross Household Density (p/sq.km)	9820	5780	7553	7461	4718	5923	6419	5997	8238	8409	5288	6619	4013	6218	1906
Floating Density (p/sq.km)	63432	-	11965	4720	-	8129	20518	-	4444	1776	-	7285	-	-	69733
DI															
Unemployment %	57.61	66.57	2.24	62.11	67.12	2.76	62.7	67.61	2.97	63.98	68.44	3.53	66.77	68.64	1.51
Literates %	80.65	91.16	100	79.6	87.95	100	76.47	86.53	100	75.94	81.35	100	66.12	77.28	100
Females per 1000 males	794.2	927	1071	834	905.5	1019	797.5	895.2	1007	800.2	882.6	1012	801	873.8	1076
Slum population % (assisted households in Tokyo)	23.02	1.12	1.42	42.56	1.58	2.26	53.44	3.95	3.07	60.54	4.21	4.08	77.55	8.07	1.73
Working females per 1000 working males	213	188	788	210	176	738	163	143	726	150	144	736	122	153	780

"Percentage of ward population living in slums" emerged as a dominant factor with a strong negative relationship with DI, i.e., as the percentage of ward population living in slums increases, the value of DI decreases.

The presence of slums strongly determined DI levels in Mumbai, where they account for over half of the city's population. Naturally, density characteristics such as high physical density, low amenity density and low autonomy density which are characteristic features of slums, showed a strong connection to low DI in the regression analysis and non-slum characteristics corresponded to areas of better DI. A similar relationship was also seen in Ahmedabad, however with a much smaller value for the coefficient of determination and less statistically significant regression coefficients. In case of Tokyo, physical density showed a positive

correlation with DI suggesting that densely populated areas in Tokyo corresponded to areas of high DI. However, the regression also showed that Intensity had a negative relationship with DI in Tokyo suggesting that areas of low DI corresponded to areas with high built density and less open areas.

8.1.1 Inter-city comparison of Built-up Intensity

It is known that the areas of highest built intensity in Mumbai and Ahmedabad are obviously the slum areas since there are next to no open areas within slum settlements. However, since the intensity data for Mumbai and Ahmedabad were not available, a comparison of satellite images taken at the same scale in all three cities, corresponding to areas of equal values of physical density were studied to see how intensity varied in each city at similar physical density values. Comparisons were made at physical density values of 10,000 persons/sq.km and 20,000 persons/sq.km (Fig. 8.2 and 8.3).

It was seen that at the same physical density, intensity was greatest in Tokyo, followed by Ahmedabad, followed by the high DI areas of Mumbai, and it was least in the low DI areas of Mumbai. The satellite images revealed that while Tokyo was very densely packed with built forms, Mumbai showed a very sparse development. It was surprising to see how areas of such differences in built intensity could still have the same gross population density. Further investigation revealed the reason for Mumbai's sparsely built-up wards.

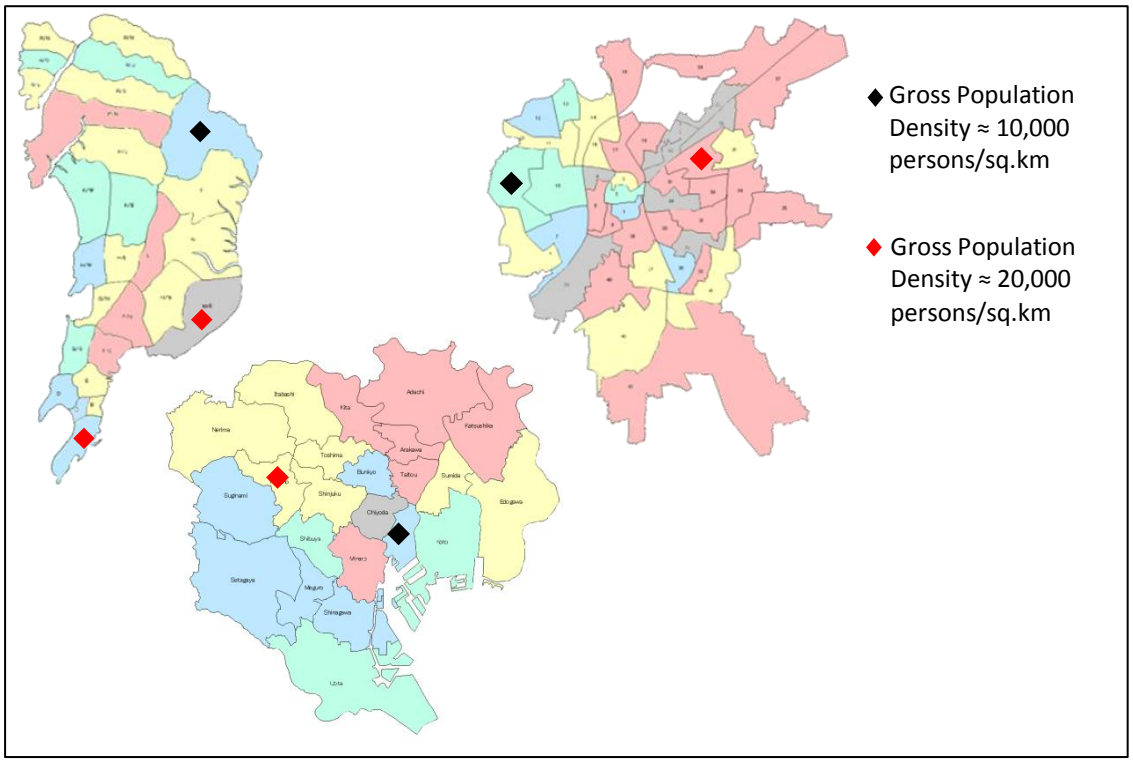


Fig. 8. 2 Areas selected for comparison of Built Intensity

Fig. 8. 3 Comparison of Built Intensity at Gross population density of approximately 20,000 persons/sq.km

While most of the ward areas were loosely compacted with buildings, certain small patches of land within the wards had clusters of very small built structures. These were found to be slums and since these tiny plots had people living in densities of 10 times or more than the non-slum areas, the overall density of the ward was still quite high in spite of the rest of the ward being low density areas. Furthermore, the non-slum areas of wards of low DI had even less density as they had a greater proportion of people residing in the slum areas.

This led to some interesting revelations. Firstly, in Tokyo, the entire population had access to the basic amenities both physical and social. The proximity to job opportunities is an important factor as people travel very long distances for work and so, autonomy had a positive relation to DI. Furthermore, urban land is a highly valued resource and there is a lot of crowding for the same. The population comprising of the low DI cluster have very limited access to urban land for residential and recreational purposes within the 23 wards, and are forced to reside in cramped conditions. High intensity therefore corresponds to low DI in Tokyo as expressed in the regression equation. In the case of Mumbai and Ahmedabad, the value of physical density does not accurately reflect the actual living density condition. It is an average of the entire ward area, which has two very distinct density types; one being low intensity development in comparison to other cities and the other being extremely dense slum settlements which have densities of

20 times more than the densest conditions in other cities, with not even a fraction of the physical and social amenities that exist in high density areas of other cities. Instead of measuring physical density of the whole ward, it is therefore important to measure the slum density and non-slum density of the wards as separate measures in order to understand the exact condition of the residential density. Therefore, a general framework of how each of the DM must be altered in order to improve DI is obtained. This is applied to form development goals for vulnerable wards identified in Mumbai.

8.2 Applications of the Macro level Statistical Analysis in wards of Mumbai

The regression of Mumbai data showed that the Amenity had the strongest weightage in predicting DI. For Amenity to be adequate sewerage connections should cover 100% of ward population and water supply should have 100% coverage with 180 LPCD of supply which is the benchmark set by MCGM. These are the bare minimum requirements towards adequate amenity. Autonomy was also an important predictor of DI and for increased Autonomy local employment ratio should be close to 1, i.e., local job density should be similar to overall average job density of the city so all wards have similar affordance of employment opportunity. Furthermore, female autonomy ratio should also follow the same proportion (Fig. 8.4).

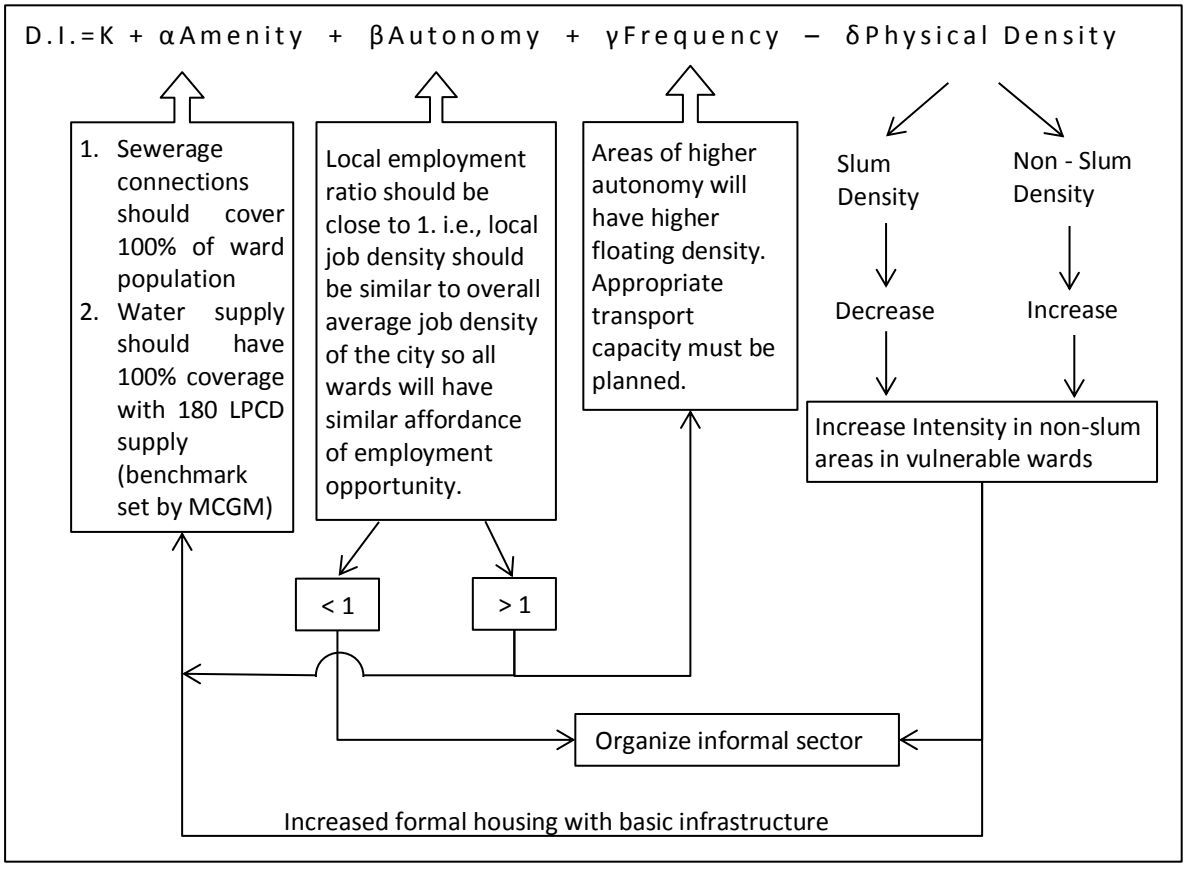


Fig. 8. 4 Proposed framework for increasing DI by modifying DM based on Mumbai

Areas of higher Autonomy will have higher Frequency which should be considered when planning for Amenity and Transport capacity. A high level of DI can be achieved by bringing about changes in the DM as mentioned above and as expressed in Fig. 8.4.

Time series data was used to notice trends in density growth in Mumbai between 2001 and 2011. This was used to identify the wards with worst existing DI and where Human Security was deteriorating further. These were identified as the vulnerable wards which needed to be the focus of immediate planning action. The time series data showed that between 1991 and 2001, a lot of population growth occurred in the southern wards of the city district whereas the suburbs hardly grew in population. The decadal growth between 2001 and 2011 was however very different from the previous trend. In this decade, most of the city wards lost population and the major growth occurred in the suburban wards of the north and east, as well as in areas of the Mumbai Metropolitan Region outside the Greater Mumbai area. Many of the wards which had been identified to have poor levels of human security through the cluster analysis (having DI values less than 0.5) had increased in density over the past decade (highlighted in yellow in Fig. 8.5). These wards were already home to a large slum population and their superannuated infrastructures were far below adequacy.

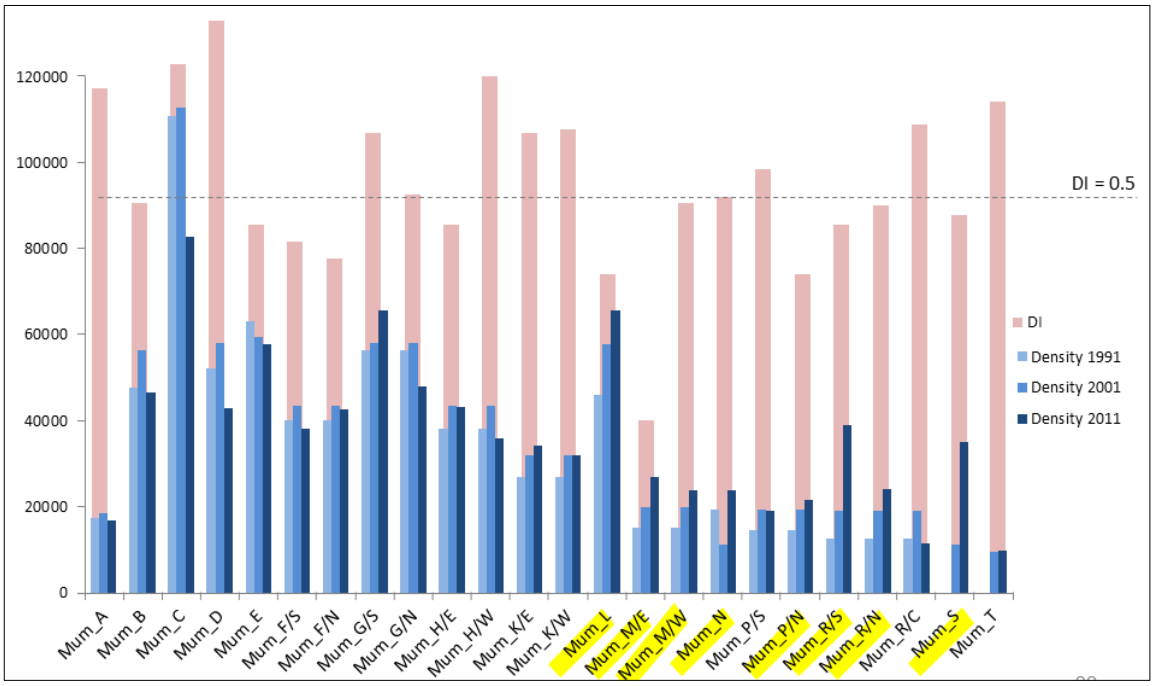


Fig. 8. 5 Wards with DI below 0.5 which showed further population growth in the past decade

In 2001 the data for these wards showed that more than 50% of households did not have access to sewerage connections, about 10% did not have water supply, 50-80% of the wards' population lived in slums and over 60% did not have stable employment. The further increase of density in these wards can be assumed to have a worsening effect on the human security of

these wards. They were therefore identified as the vulnerable wards and were namely wards L, M/E, M/W, N, P/N, R/N, R/S and S showed in Fig. 8.6.

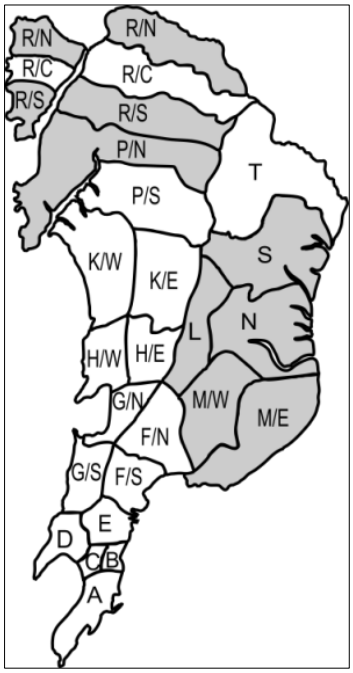


Fig. 8. 6 Vulnerable wards

The DI and DM datasets of these wards were compared to see how they compared to each other. L ward showed the highest share of slum area and was among the lowest in DI (Fig. 8.7). It also had highest density in 2001 which continued to grow over the decade which can be assumed to add to slum population. Ward L was therefore identified to be the most vulnerable ward in Mumbai.

Several development goals were framed for ward L using the function explained in Fig. 8.4. Since the function states that sewerage connections should cover 100% of ward population and water supply should have 100% coverage with 180 LPCD supply, the exact number of sewerage connections and water supply connections needed to achieve this, was calculated. The existing shortage was calculated from the 2001 data on amenity. The additional demand between 2001 and 2011 was projected using the increase in population of the ward and the average household size. The resulting water supply connections required in 2011 was 3510 connections and sewerage connections needed were 90460 connections. Autonomy increase required the local employment ratio to be 1. In case of ward L, the unemployment percentage was 64.40 % in 2001. Although the local job density was better than the average for the city, it was seen that the proportion of informal jobs was much higher than the main jobs. Thus, cluster development of informal sector for increased stability and economic gain was prescribed as a development goal. Additionally, the female autonomy of the ward was very low as only

11% of total workers were female and the increase in female autonomy must therefore be a priority in the ward. The next DM of Physical Density is treated in two parts in the function stated in the previous section; slum density and non-slum density. These values were therefore calculated to understand the difference between them and help to guide the intensification of non-slum areas to dissipate and formalise the slum areas. 658,972 people lived in 3.69 sq. km of slum area in ward L whereas 119,246 people lived in 13.39 sq.km of non-slum areas. The physical density was therefore 178,583 persons/sq.km and 8,906 persons/sq.km in slum areas and non-slum areas respectively.

A similar calculation for projected requirements of Amenity was done for all the vulnerable wards and the total capacity increase required was calculated. The benchmark set by the Municipal Corporation of Greater Mumbai on the amount of water to be supplied daily states it as 180 LPCD. Adding the required number of households to be supplied, it is seen that an additional amount of 171 million litres will be required daily, to serve the population in just these 8 vulnerable wards. The current reservoir capacity for entire Mumbai is 1864 million litres daily. An increase of 171 million litres is nearly one-tenth increase from current daily capacity. Such calculations may prove to be quite helpful for taking local area and city wide planning decisions.

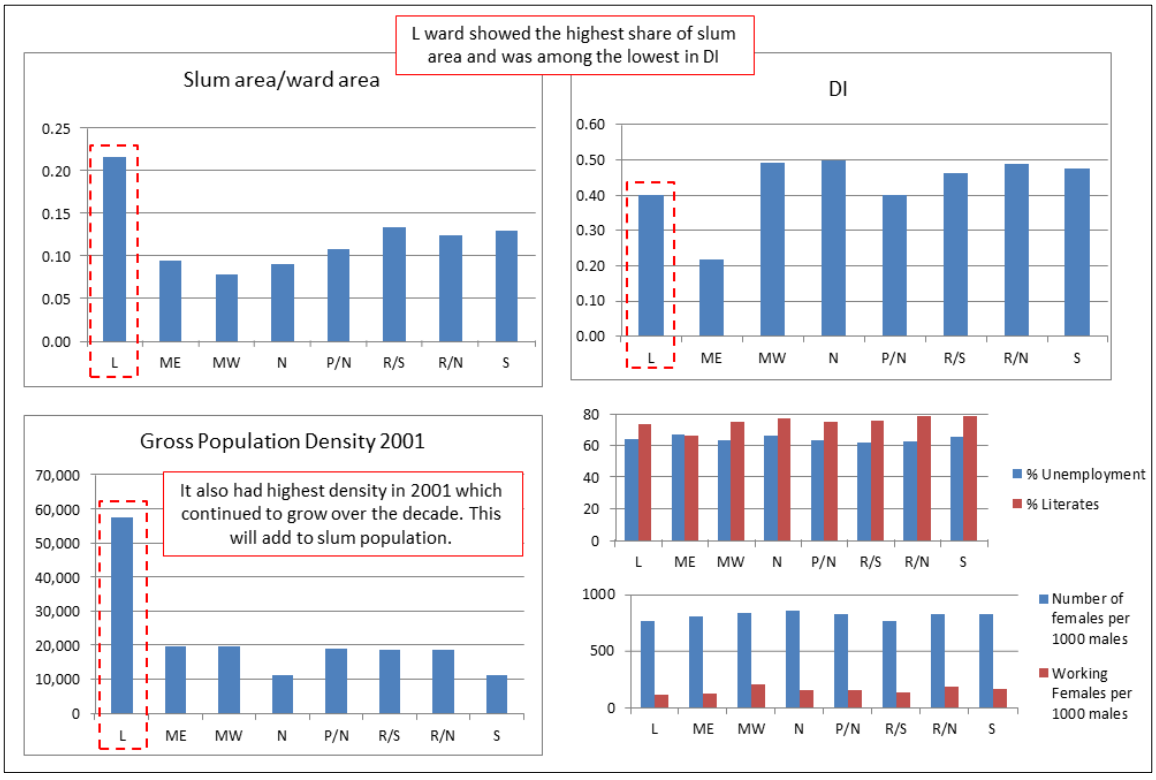


Fig. 8. 7 Comparison of vulnerable wards

8.3 Micro- level Mesh Analysis

Following the macro analysis, a micro level mesh analysis was carried out in three wards; A, ME and MW of Mumbai, which belong to very high, average and very poor DI levels respectively (Fig. 8.8).

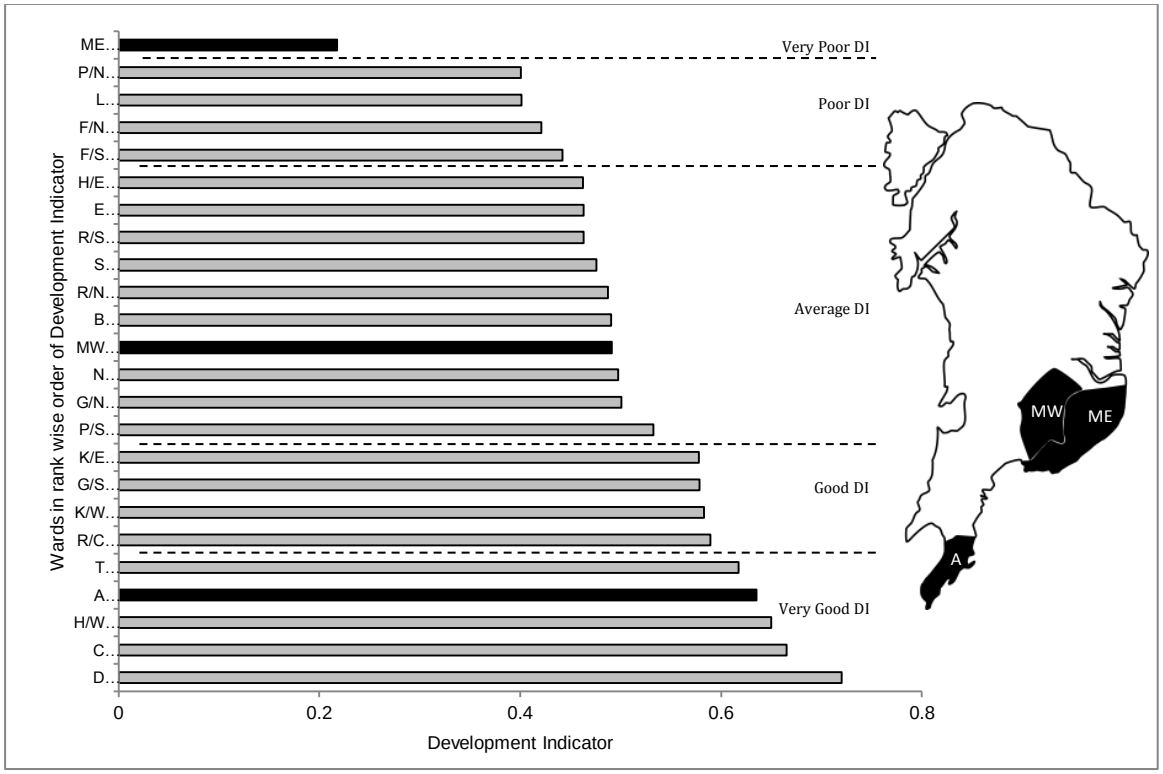


Fig. 8. 8 Wards selected for mesh analysis

The attributes investigated were, economic residential grades, built /un-built ratio, and number of floors.

A field study was carried out in the city through which 7 different grades of residential types could be observed based on the economic status of the residents, identified through observable physical characteristics (Table 8.3) which were recorded through reconnaissance survey on maps during the field visit and extensively photographed from two different viewpoints; street level and rooftop level of tall buildings providing vantage points over the adjoining areas (Fig. 8.9). These 7 housing grades were mapped onto a grid of cell sizes of 500m x 500m superimposed on the wards (Fig. 8.10). The mapping was done using ArcGIS software. Firstly, a high resolution satellite image of the area to be analysed was acquired from Google Earth (multiple images taken at elevation of 20m from ground were joined using Adobe Photoshop to create one high resolution image of the entire ward) and geo-referenced using coordinates of 5 prominent landmarks of the ward. These landmarks included permanent features such as important buildings, bridges, rail stations, and road junctions. Next, a grid of

500m x 500m was superimposed on the satellite image with a code assigned to each cell. Each grid cell was marked according to the numbers representing each housing grade. The numbers were entered in the attribute table corresponding to each coded cell and then joined to the attribute table of the geo-referenced image in GIS. In grid cells which contained more than one type of housing grade, the scoring was done corresponding to the one occupying the majority of the cell. The percentage of mesh cells corresponding to the frequency of each of the 7 housing grades were calculated for each ward (Fig. 8.11). Two other attributes; built /un-built ratio, and number of floors were also similarly mapped.

Ward A, the Very High DI ward showed a much higher share of its residences in housing grades 1 and 2 than any of the other wards. Wards ME and MW both showed a high percentage of slums (grades 5, 6, and 7) as well as MIG and LIG residential areas. This is concurrent with the macro-level cluster analysis. Wards M/E and M/W which belong to two different DI clusters showed that many contiguous areas of slum patches and middle income institutional housing spanned across their ward boundaries.

Fig. 8. 9 Photo showing street level and aerial view of a neighbourhood in ward MW

Table 8. 3 Housing Grades

Housing Grade		Location	Facade	Architectural character	Observed amenities
1	High Income Group (HIG)	High value land close to hubs of business or commerce	Signature façade (e.g. art deco) Very well maintained	Usually high rise or individual mansions	Garden, swimming pool, security guard, gated
2	Middle Income Group (MIG)	Suburbs, transport nodes, govt. land, etc.	Standard, maintained	Functional, mid to high rise	Gated, security guard optional
3	Low Income Group (LIG)	Govt. land, rehabilitated slum area	Very old, poor quality, poor maintenance	Mid-rise. Slum rehab buildings are high rise	None. Also, very closely packed
4	Chawl	Near old industrial areas	Long shared balcony, poor maintenance	Small quarters accessed by shared passage	None. Usually have piped water supply, sewerage and electricity
5	Slum with commerce /industry	Road facing areas of slums	Shop/industry on ground / all floor	Brick masonry, metal sheet roof	None. Usually have common water, toilets
6	Mature Residential Slum	Inner areas of slums, railway line	Door opening, ladder to upper floor	Brick masonry, metal sheet roof	None. Usually have common water, toilets
7	Squatter tenements	Marginal land	Shanty	Scavenged materials, unstable structure	None

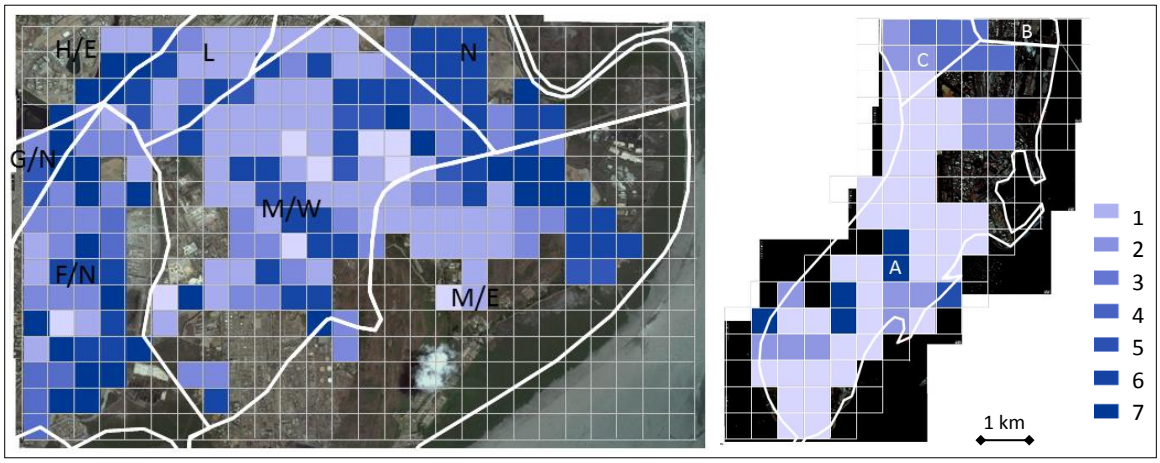


Fig. 8. 10 Housing Grades mapped on M/W, M/E (left) and A (right)

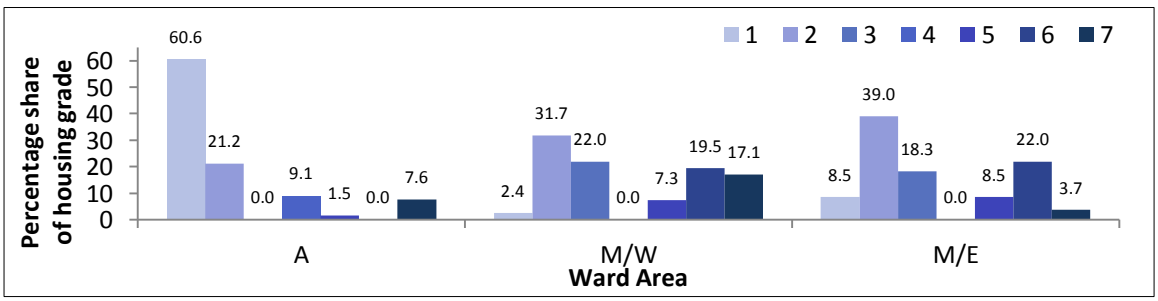


Fig. 8. 11 Percent shares of housing grades in wards of different DI

From Fig. 8.10 it is apparent that there is a clear divide between the north-east and south-west parts in this area, with the former mostly comprising slum areas and the latter grade 2 housing. On closer observation it is seen that this divide is along the railway line. The slums are to the north of the railway line near the large slaughter houses and garbage dump.

Next, the mesh cells were assigned values corresponding to two more attributes assessed from the field visit and from satellite imagery. The first of these was the percentage of built-up area in total area (BUA), which was marked on each cell for all 3 wards. The scores assigned were 1, 2, 3, 4 and 5 corresponding to built-up percentage of <=20%, 21-40%, 41-60%, 61-80% and >80% respectively. The second attribute marked was average numbers of floors with scores of 1, 2, 3, 4, 5, 6 and 7 corresponding to 1 floor, 2 floors, 3 or 4 floors, 5-7 floors, 8-12 floors, 13-19 floors and >19 floors respectively. ArcGIS was used to generate the mesh maps corresponding to these scores and are shown in Fig. 8.12, 8.13.

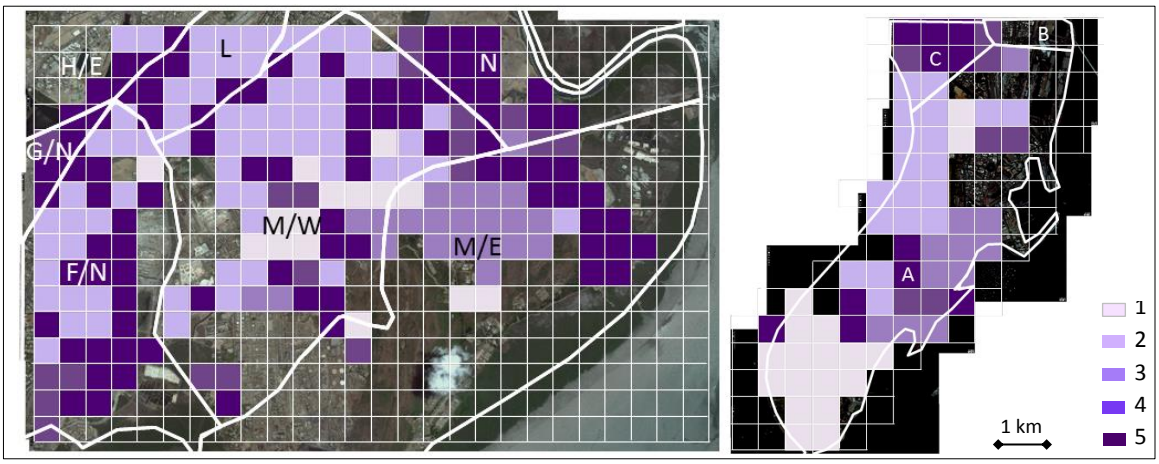


Fig. 8. 12 Built-up areas mapped on M/W, M/E (left) and A (right)

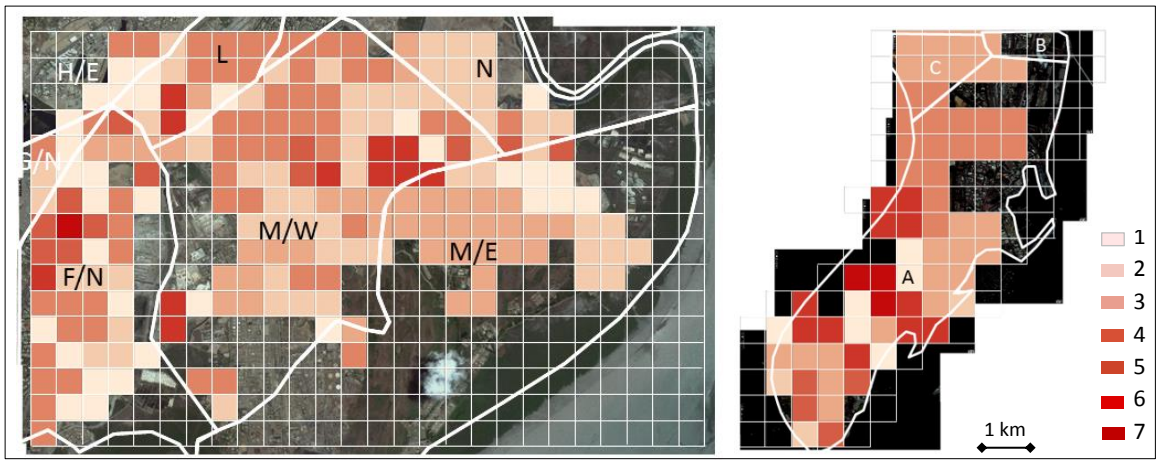


Fig. 8. 13 Floors mapped on M/W, M/E (left) and A (right)

The attributes of percentage of built-up area (BUA) and average number of floors represent the built intensity of each cell in the mesh. These attributes were specifically selected

for the macro level mesh analysis for three reasons. Firstly, suitable data representing intensity had not been found at the ward-wise level due to which the relationship between intensity and DI of Mumbai had been unexplored. Secondly, radical differences in the built up characteristics of slum areas and non-slum areas had been noticed which needed investigation to see if space crowding presented lower DIs. And thirdly, areas of identical physical density in Tokyo and Mumbai had presented with very different intensity characteristics. The built intensity was much higher in Tokyo but in Mumbai there existed slum pockets within low intensity zones which contributed to extremely high populations hence increasing the overall physical density of the area. Mumbai therefore has a wide variety of intensity gradients within each of its wards which need to be investigated.

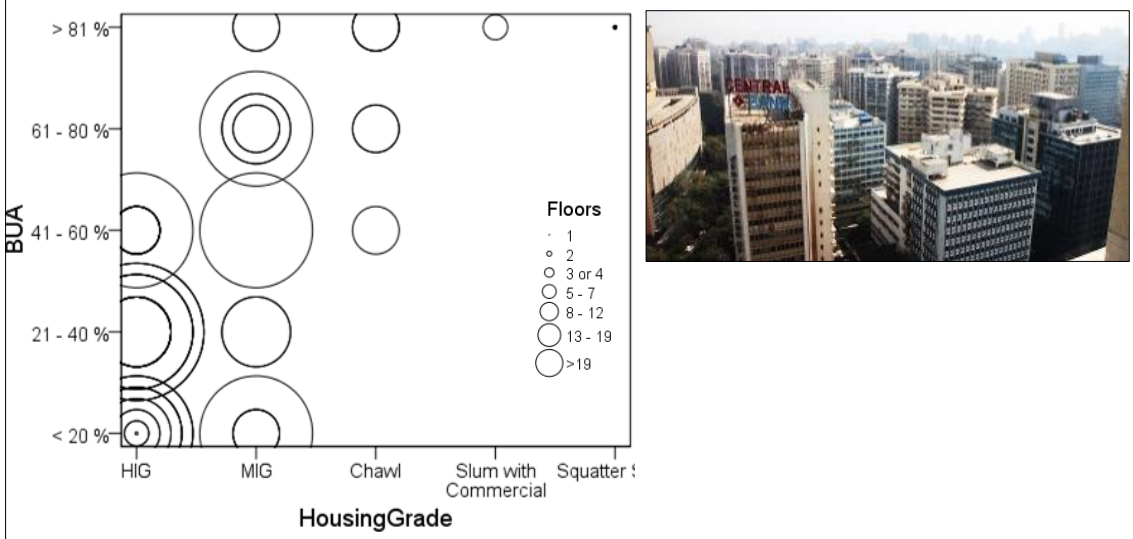
The three attributes were plotted to produce bubble charts for each of the wards; A, M/W and M/E (Fig. 8.14). Furthermore, Pearson's correlation co-efficients were calculated which showed a very high level of correlation significant at the 0.01 level (Table 8.4). Furthermore, a regression analysis using Housing Grade as the dependent variable and the intensity variables of BUA and average number of floors as the independent variables showed a very high co-efficient of determination (R^2 value) for linear regression (Table 8.4).

Table 8. 4 Pearson's correlation, R^2 and regression coefficients of attributes

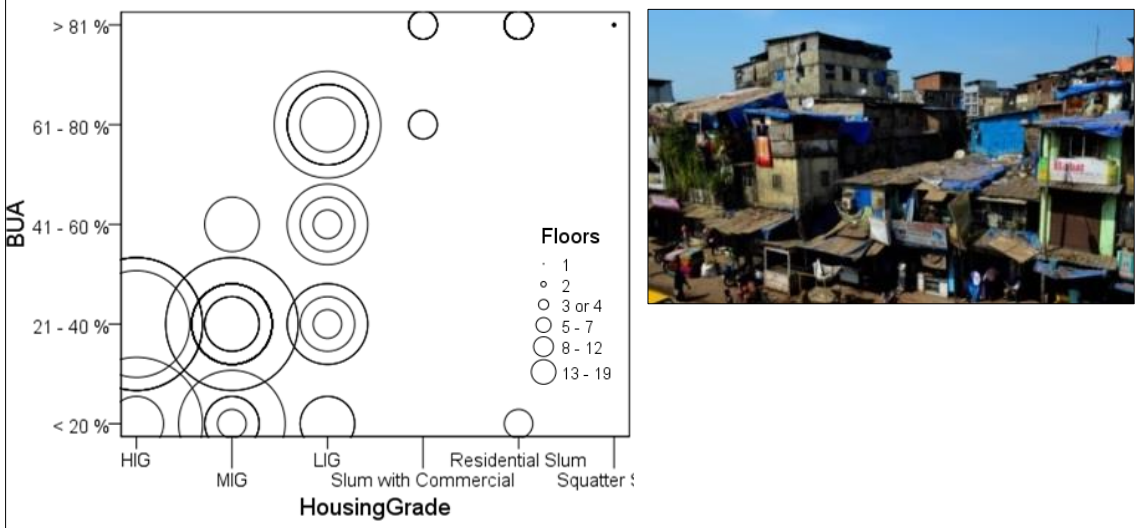
	Pearson's Correlation Coefficients			Adjusted R^2	Regression Coefficients	
		BUA	Floors		BUA	Floors
Ward A – Very Good DI	**Housing Grade**	0.724	-0.587	0.605	0.706	-0.353
	BUA		-0.464			
Ward M/W – Average DI	**Housing Grade**	0.863	-0.823	0.872	0.711	-0.661
	BUA		-0.635			
Ward M/E – Very Poor DI	**Housing Grade**	0.826	-0.815	0.820	0.822	-1.106
	BUA		-0.643			

This analysis was designed to investigate the hypothesis made in the previous section that in Mumbai, areas of highest physical density which correspond to slum areas within each ward are the areas of lowest DI. The housing grade is a good reflection of the socio-economic capability of a person and so stands for DI. The built/un-built ratio and the number of floors reflect the intensity. If the size of dwelling unit and local densities had been known, then the exact residential density could have been found. However, in the absence of such data, the attributes used to represent intensity give a fairly good idea of the residential density characteristics. The results of the mesh analysis showed that lower built /un-built ratio and higher number of floors correspond to better housing grades across all three wards. So, higher and middle income groups residences correspond to mid to high rise buildings with less ground coverage and more open space area whereas slums have very little open space and are mostly low rise.

Ward A – Very Good DI



Ward M/W – Average DI



Ward M/E – Very Poor DI

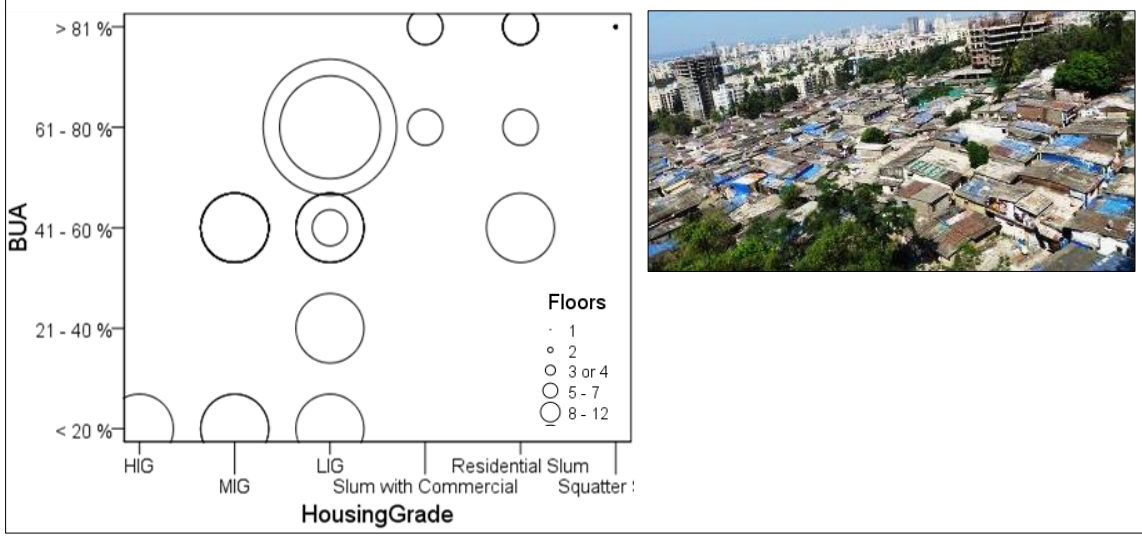


Fig. 8. 14 Bubble plots of attribute frequencies and photographs of typical ward characteristics

This pattern is consistent in all the areas analysed regardless of the DI cluster membership of the area. The differentiating factor observed in relation to very good, average and very poor DI clusters was that the slums and squatter settlements were lesser in number in ward A and very high in ward M/E. This leads us to believe that in Mumbai, similar residential characteristics can be found in all the wards but the frequency of certain types of residential character influence the overall DI of the wards. Owing to the vertical stacking in the better housing grades which is absent in slums and squatters, and without the knowledge of the number of people residing in each building, it is difficult to comment on the amount of open space and residential space available to people of high DI and low DI areas. It can however be assumed that in the high rise buildings, even if a small open area is under use by a very large number of people, its dedicated role as a breathing space and an area for recreation adds value to its users. In slums, such areas are altogether absent. A similar mesh analysis done in Tokyo could similarly help in confirming the intensity characteristics that directly correspond to low DI.

8.4 Mathematical modelling of DM for increased DI

Since a strong relationship between DI and DM had been established by the macro level statistical analysis and the micro level mesh analysis done thus far, an attempt was made to find a mathematical function using which DM could be modelled using DI.

The DI composites of each ward were plotted in their rank-wise order in each city (Fig.8.15, Fig.8.16 and Fig.8.17). This is a visual representation of the DI inequality between the wards in each city. The greater the inter-ward inequality of DI, the DI distribution will tend to resemble an exponential curve. The curve will get flatter as the inter-ward DI inequality decreases. A line plotting the rank-wise DI values would therefore have a slope corresponding to the inequality between the wards of the city.

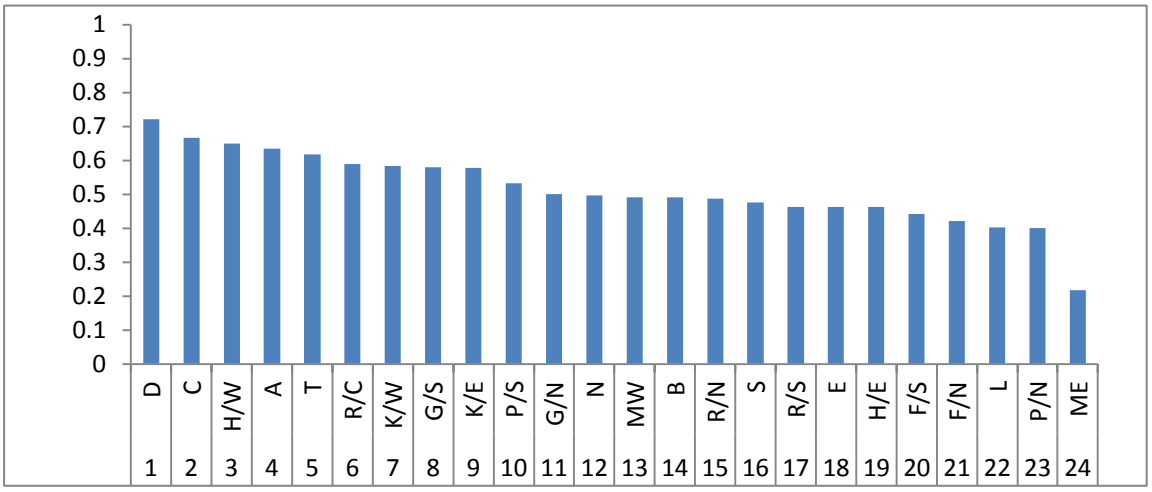


Fig. 8. 15 Rank-wise DI levels of Mumbai wards

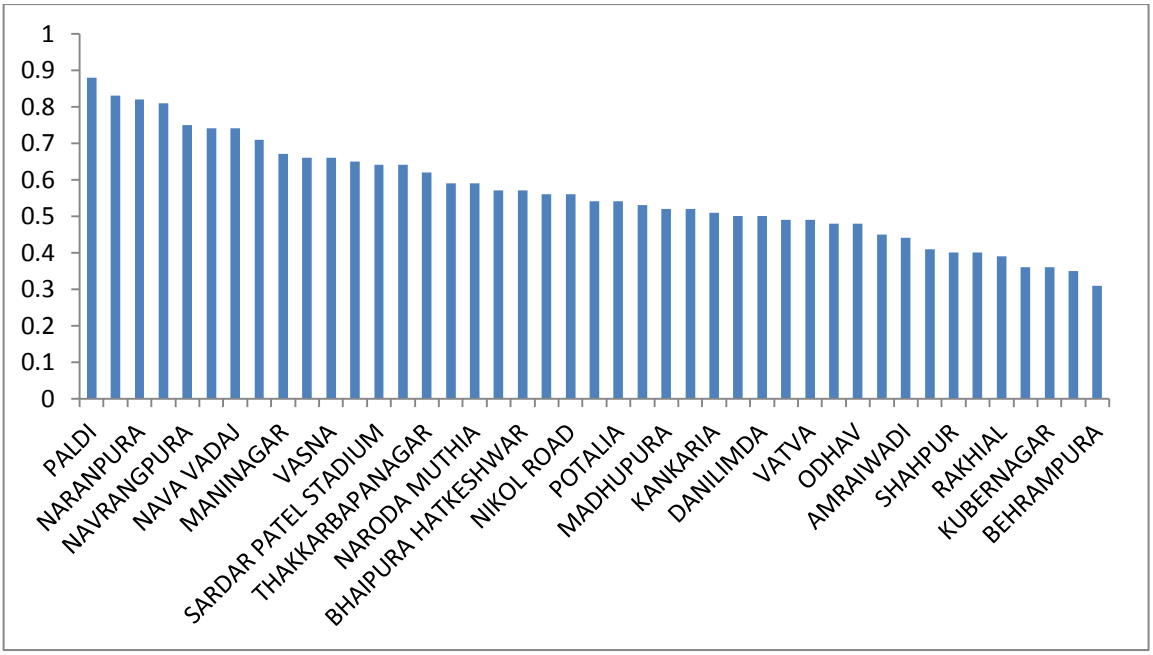


Fig. 8. 16 Rank-wise DI levels of Ahmedabad wards

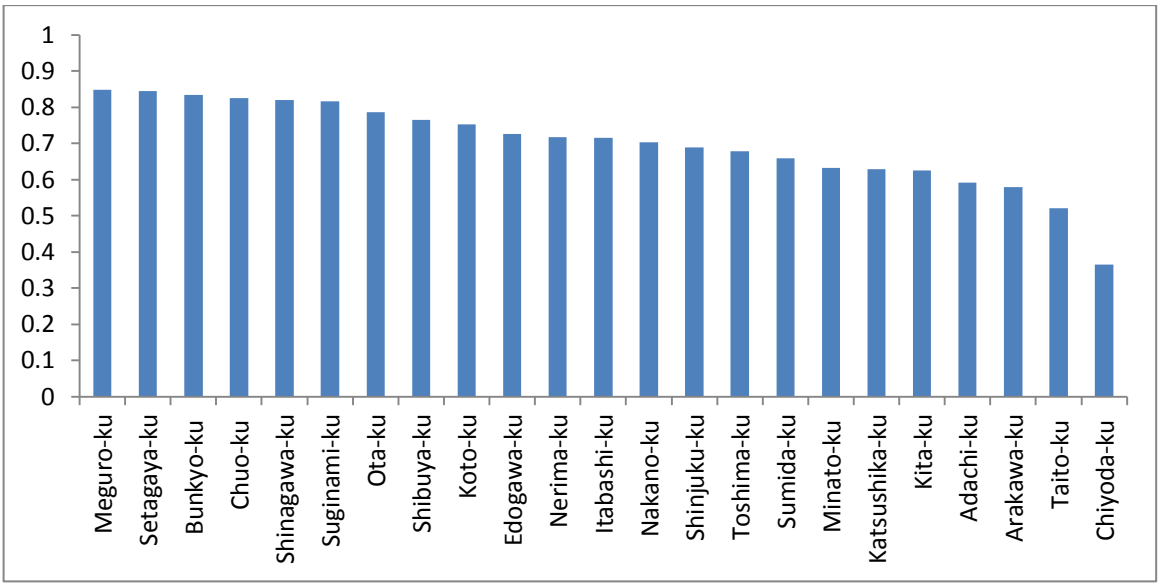


Fig. 8. 17 Rank-wise DI levels of Tokyo wards

Urban density has traditionally been modelled using density gradient functions which model urban density in the physical space using scales such as “distance from CBD”, “time taken to travel to work”, “city size”, etc. The “Negative Exponential Density Function” (Equation 8.1 a) and “Inverse Power Function” (Equation 8.1 b) are widely accepted as effective density gradient functions for modelling urban density.

a. Negative exponential function: $D_x = D_0 e^{bx}$	D_x – Average density at distance x from CBD
	D_0 – Average density at CBD
b. Inverse power function: $D_x = D_0 x^{-b}$	x – Distance from CBD
	b – Rate at which the effect of distance attenuates

Equation 8. 1 Negative exponential density function and inverse power function

The attempt here was to use the same mathematical functions, but model the Density Measures on the gradient of DI variation between DI clusters. Drawing a direct analogy therefore, it was proposed that the "Average density at CBD"(D_0) be replaced by "DM values at 'Very Good' DI cluster" (DM_1), "distance from CBD"(x) be replaced by the "respective rank of the DI cluster at which DM is being predicted" (x), and "Average density at distance x from CBD" (D_x) be replaced by "Average DM at DI Cluster rank x"(DM_x). Furthermore, the "rate at which effect of distance attenuates" (b) is replaced by the "rate at which DI decreases at each cluster", which is also the slope of the curve representing rank-wise DI (y'). The expressions used to model DM are shown in (Equation 8.2 a and b).

a. Negative exponential function: $DM_x = DM_1 e^{y'x}$	DM_x – Average DM at DI Cluster rank x
	DM_1 – DM values at 'Very Good' DI cluster (rank 1)
	x – Rank of the DI cluster at which DM is being predicted
b. Inverse power function: $DM_x = DM_1 x^{y'}$	y' – rate at which DI decreases at each cluster

Equation 8. 2 Functions used to model DM

8.4.1 Modelling DM in Mumbai

The cluster average of the DI distribution was plotted for Mumbai and a polynomial fitted to represent it (Fig. 8.18).

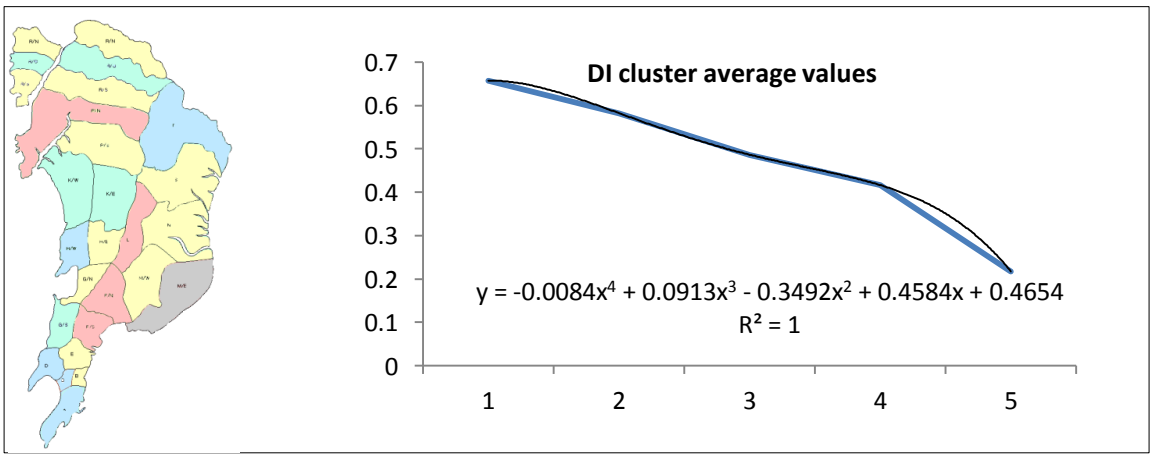


Fig. 8. 18 Distribution of DI cluster average values in Mumbai

The polynomial equation best fitting the average values of DI was found to be:

$$y = -0.0084x^4 + 0.0913x^3 - 0.3492x^2 + 0.4584x + 0.4654 \quad \text{----------} \quad \text{i}$$

So, gradient of tangent can be found by differentiation to find y':

$$y' = -0.0336x^3 + 0.2739x^2 - 0.6984x + 0.4584 \quad \text{----------} \quad \text{ii}$$

Substituting x as each of the cluster rank values in ii, y' can be obtained as follows:

For Cluster 2, $x=2$, $y' = -0.1116$
For Cluster 3, $x=3$, $y' = -0.0789$
For Cluster 4, $x=4$, $y' = -0.1032$
For Cluster 5, $x=5$, $y' = -0.3861$

The DM_x can be modelled by substituting values of DM_1, x, and y' in equations 8.2 a and b. The DM_x values calculated using Equation 8.2 a are shown as DM_a and those calculated using Equation 8.2 b are shown as DM_b in Table 8.5. The actual values are shown as "DM" in the table.

Table 8. 5 Actual and predicted values of DM in Mumbai

Cluster	DI	Physical			Amenity			Autonomy			Frequency			DM		
		DM	DM_a	DM_b	DM	DM_a	DM_b	DM	DM_a	DM_b	DM	DM_a	DM_b	DM	DM_a	DM_b
1	0.66	0.31	0.31	0.31	0.66	0.66	0.66	0.47	0.47	0.47	0.32	0.32	0.32	0.43	0.43	0.43
2	0.58	0.34	0.25	0.29	0.62	0.53	0.61	0.40	0.38	0.43	0.01	0.25	0.29	0.32	0.34	0.40
3	0.49	0.32	0.25	0.29	0.55	0.52	0.61	0.29	0.37	0.43	0.06	0.25	0.29	0.30	0.34	0.39
4	0.42	0.43	0.21	0.27	0.54	0.44	0.57	0.36	0.31	0.41	0.00	0.21	0.27	0.30	0.28	0.37
5	0.22	0.25	0.05	0.17	0.20	0.10	0.35	0.19	0.07	0.25	0.00	0.05	0.17	0.18	0.06	0.23

These predicted values were plotted (Fig. 8.19) where deviations from actual values can be seen.

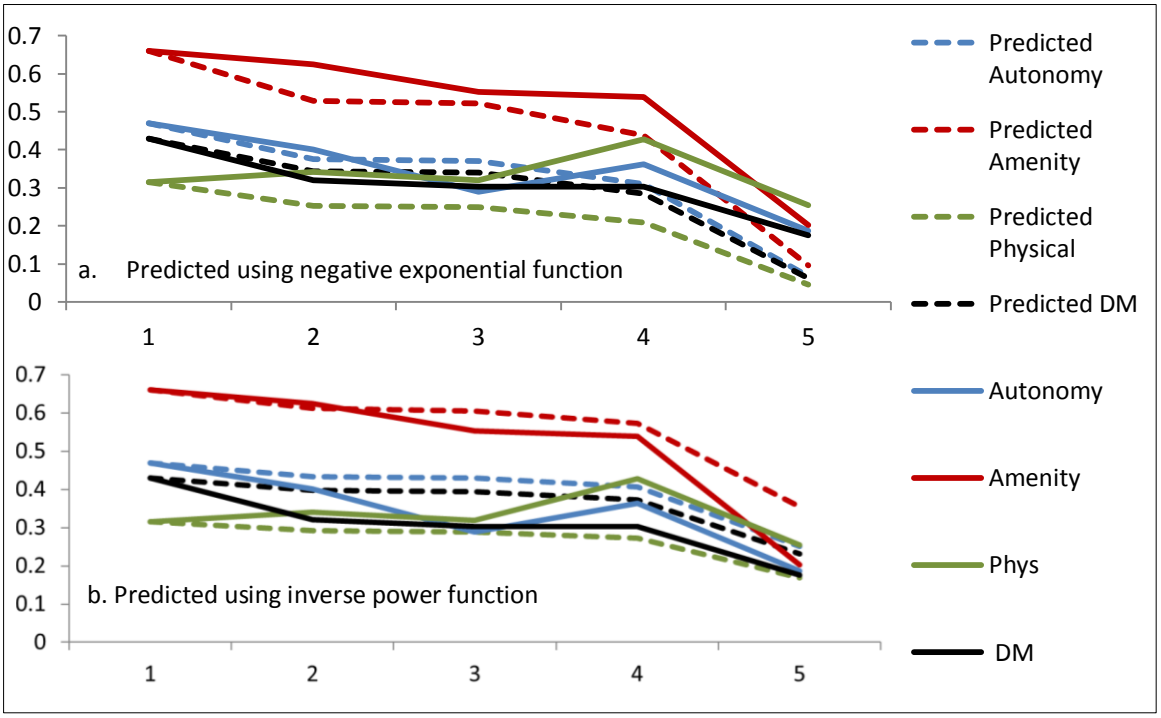


Fig. 8. 19 Graph showing actual and predicted DM values for Mumbai

8.4.2 Modelling DM in Ahmedabad

The cluster average of the DI distribution was plotted for Ahmedabad and a polynomial fitted to represent it (Fig. 8.20).

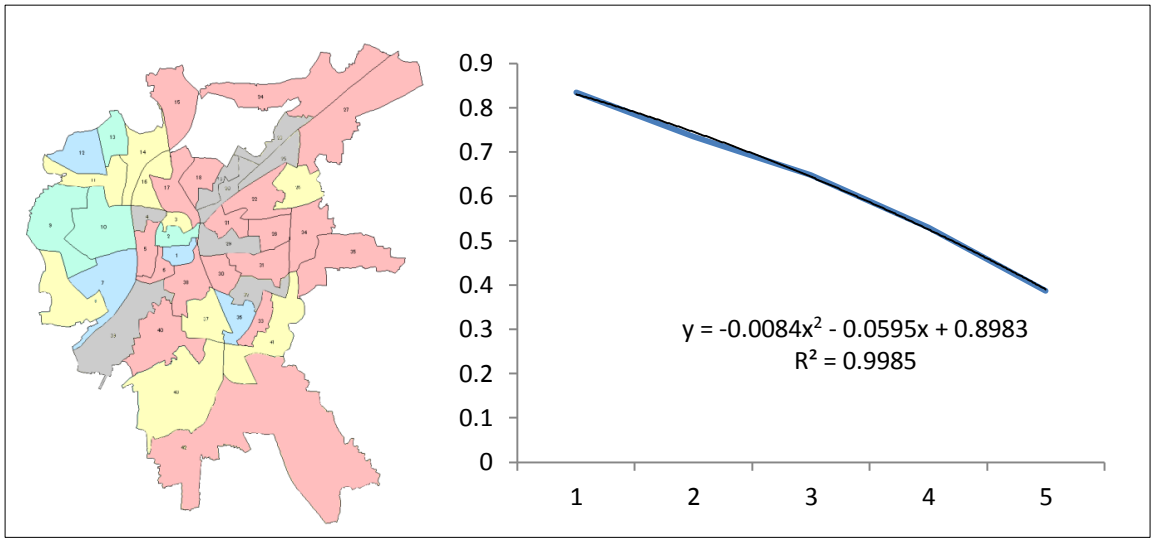


Fig. 8. 20 Distribution of DI cluster average values in Ahmedabad

The polynomial equation best fitting the average values of DI was found to be:

$$y = -0.0084x^2 - 0.0595x + 0.8983 \quad \text{---------- iii}$$

So, gradient of tangent can be found by differentiation

$$y' = -0.0168x - 0.0595 \quad \text{---------- iv}$$

Substituting x as each of the cluster rank values in iv, y' can be obtained as follows:

For Cluster 2, $x=2,\ y' = -0.0931$
For Cluster 3, $x=3,\ y' = -0.1099$
For Cluster 4, $x=4,\ y' = -0.1267$
For Cluster 5, $x=5,\ y' = -0.1435$

The DM_x can be modelled by substituting values of DM_1, x, and y' in equations 8.2 a and b. The DM_x values calculated using Equation 8.2 a are shown as DM_a and those calculated using Equation 8.2 b are shown as DM_b in Table 8.6. The actual values are shown as "DM" in the table.

Table 8. 6 Actual and predicted values of DM in Ahmedabad

Cluster	DI	Physical			Amenity			Autonomy			DM		
		DM	DM_a	DM_b	DM	DM_a	DM_b	DM	DM_a	DM_b	DM	DM_a	DM_b
1	0.84	0.69	0.69	0.69	0.58	0.58	0.58	0.68	0.68	0.68	0.65	0.65	0.65
2	0.74	0.75	0.57	0.65	0.78	0.48	0.54	0.58	0.56	0.64	0.70	0.54	0.61
3	0.65	0.66	0.50	0.61	0.40	0.41	0.51	0.52	0.49	0.60	0.53	0.47	0.57
4	0.53	0.70	0.42	0.58	0.26	0.35	0.48	0.31	0.41	0.57	0.42	0.39	0.54
5	0.39	0.64	0.34	0.55	0.31	0.28	0.46	0.29	0.33	0.54	0.41	0.32	0.51

These predicted values were plotted (Fig. 8.21) where deviations from actual values can be seen.

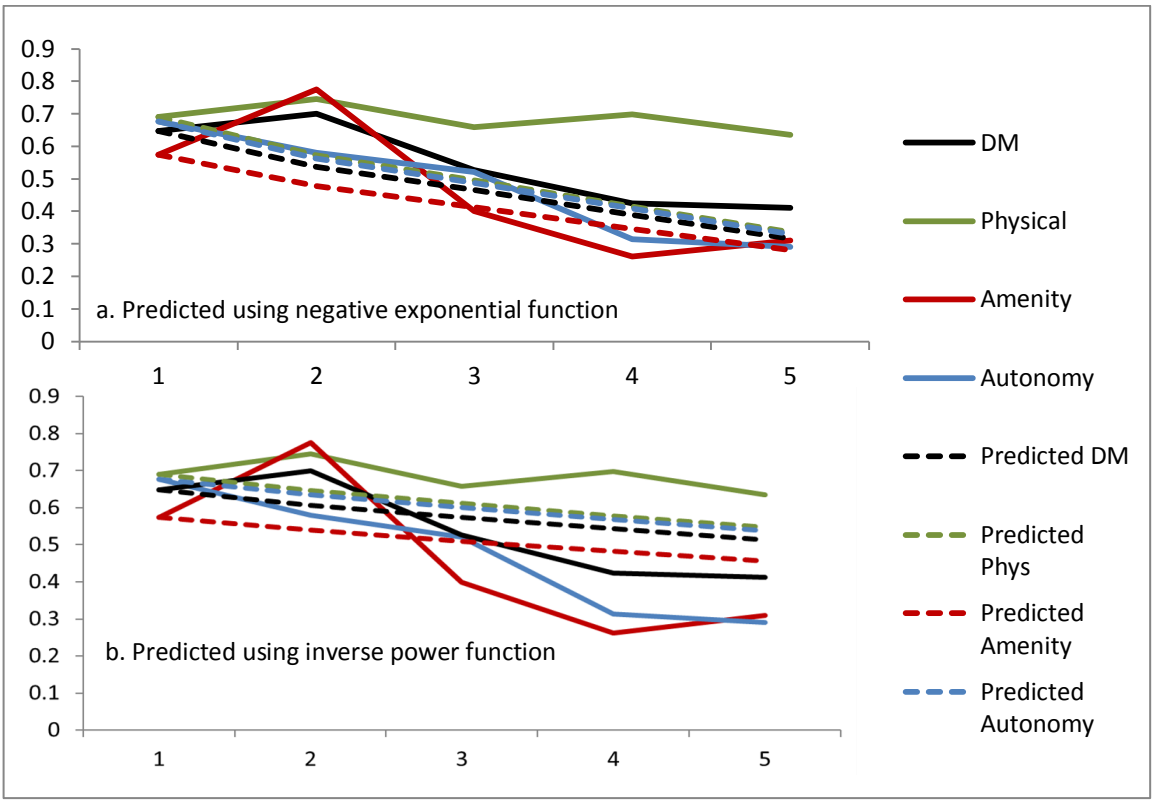


Fig. 8. 21 Graph showing actual and predicted DM values for Ahmedabad

8.4.3 Modelling DM in Tokyo

The cluster average of the DI distribution was plotted for Tokyo and a polynomial fitted to represent it (Fig. 8.22).

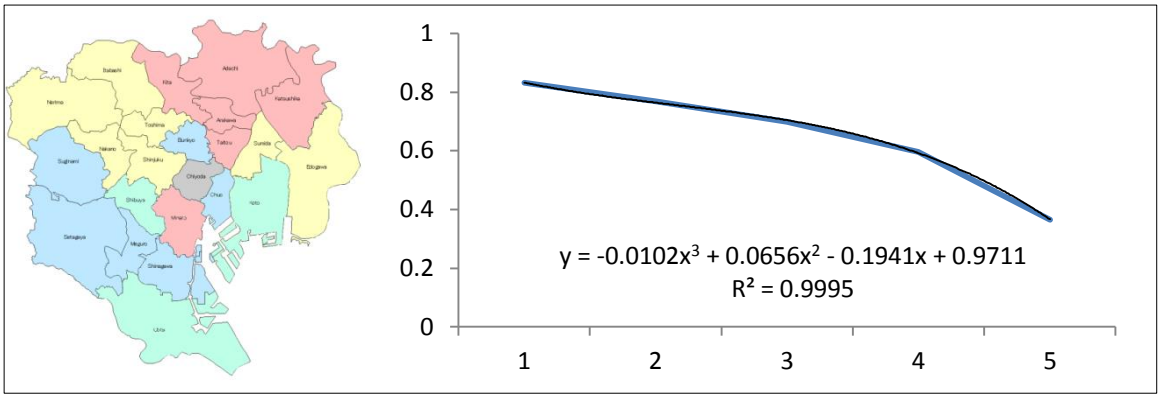


Fig. 8. 22 Distribution of DI cluster average values in Tokyo

The polynomial equation best fitting the average values of DI was found to be:

$$y = -0.0102x^3 + 0.0656x^2 - 0.1941x + 0.9711 \quad \text{----------} \quad \text{v}$$

So, gradient of tangent can be found by differentiation:

$$y' = -0.0306x^2 + 0.1312x - 0.1941 \quad \text{----------} \quad \text{vi}$$

Substituting x as each of the cluster rank values in vi, y' can be obtained as follows:

For Cluster 2, $x=2$, $y' =$ *-0.0541*
For Cluster 3, $x=3$, $y' =$ *-0.0759*
For Cluster 4, $x=4$, $y' =$ *-0.1589*
For Cluster 5, $x=5$, $y' =$ *-0.3031*

The DM_x can be modelled by substituting values of DM_1, x, and y' in equations 8.2 a and b. The DM_x values calculated using Equation 8.2 a are shown as DM_a and those calculated using Equation 8.2 b are shown as DM_b in Table 8.7. The actual values are shown as "DM" in the table.

Table 8. 7 Actual and predicted values of DM in Tokyo

Cluster	DI	Physical			Intensity			Amenity			Autonomy			Frequency			DM		
		DM	DM_a	DM_b	DM	DM_a	DM_b	DM	DM_a	DM_b	DM	DM_a	DM_b	DM	DM_a	DM_b	DM	DM_a	DM_b
1	0.83	0.67	0.67	0.67	0.54	0.54	0.54	0.25	0.25	0.25	0.44	0.44	0.44	0.20	0.20	0.20	0.42	0.42	0.42
2	0.77	0.48	0.60	0.64	0.32	0.49	0.52	0.36	0.22	0.24	0.55	0.39	0.42	0.15	0.18	0.19	0.37	0.38	0.40
3	0.70	0.76	0.53	0.61	0.66	0.43	0.50	0.24	0.20	0.23	0.48	0.35	0.40	0.10	0.16	0.18	0.45	0.33	0.38
4	0.60	0.59	0.35	0.53	0.67	0.29	0.44	0.43	0.13	0.20	0.38	0.23	0.35	0.14	0.11	0.16	0.44	0.22	0.34
5	0.37	0.00	0.15	0.41	0.00	0.12	0.33	0.45	0.05	0.15	0.00	0.10	0.27	1.00	0.04	0.12	0.29	0.09	0.26

These predicted values were plotted (Fig. 8.23) where deviations from actual values can be seen.

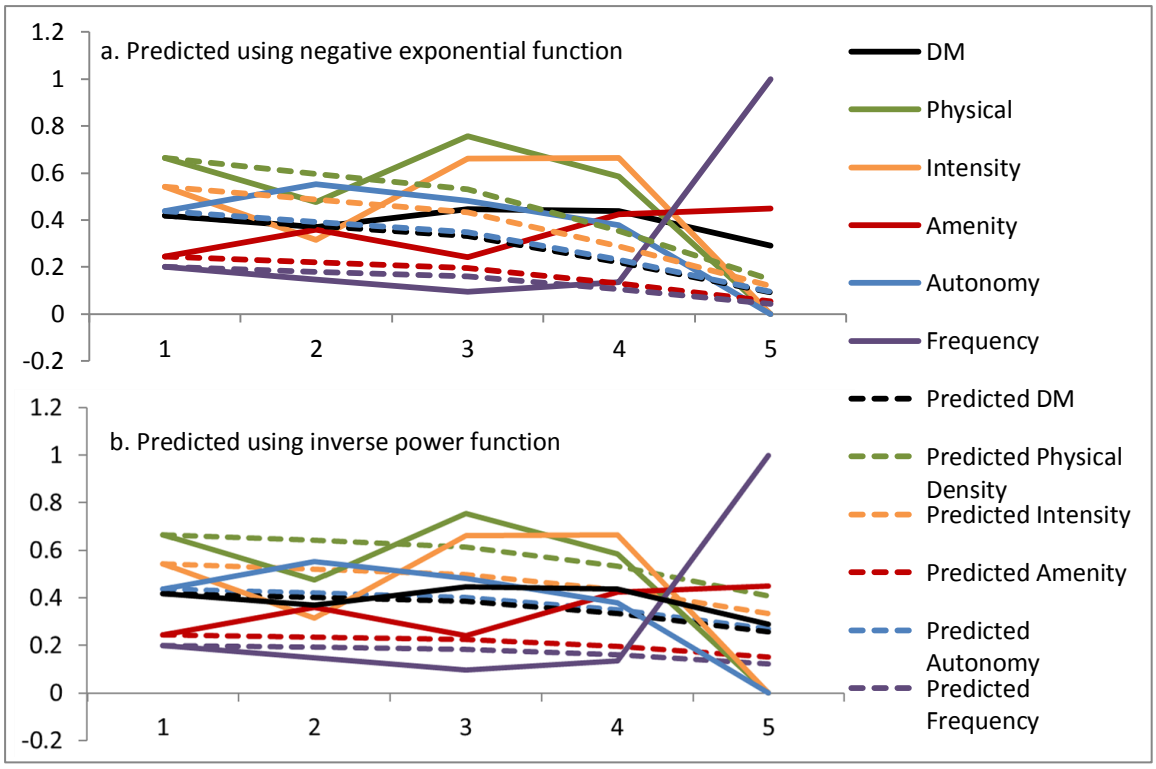


Fig. 8. 23 Graph showing actual and predicted DM values for Tokyo

8.4.4 Results of Mathematical modelling of DM for increased DI

A Pearson's correlation analysis was done to see the correlation of the actual DM values with those predicted by equation 8.2 a and equation 8.2 b. The corresponding correlation coefficients are shown in the Table 8.8.

The same mathematical models are applicable in cities of very different characteristics in significantly modelling DM values according to the variation of DI. The DM could be modelled using the negative exponential function (a) and inverse power function (b) in each city. The Pearson's correlation coefficient found for all the predicted DM results was high ($r > 0.5$). However, not all of the coefficients were significant (p-value < 0.05 is taken as significant). This may have been due to the very small dataset and in the absence of more significant results no universal conclusion can be stated. It may however be assumed that the DM, especially those that had shown a strong relationship with DI in the regression analysis, can be predicted by the negative exponential and inverse power functions across all wards in each city. This suggests that DM and DI values are intrinsically connected, i.e., the human security of the residents of a city is closely related to the density measures expressing the crowding they experience for various urban resources and systems. The development policy framed to affect these specific DM in the respective DI clusters can produce effective results in improving the DI of the residents of these areas, hence reducing the socio-economic gap, enabling capabilities, and bringing about a more sustainable urbanization in developing countries.

Table 8. 8 Pearson's Correlation Coefficient for DM values predicted using functions 'a' (negative exponential) and 'b' (inverse power) in Study Areas

Correlation between actual and predicted	Mumbai		Ahmedabad		Tokyo	
	a	b	a	b	a	b
Physical	.426	.515	.543	.563	.790	.833
Intensity	NA	NA	NA	NA	.561	.622
Amenity	.982**	.992**	.745	.767	-.818	-.801
Autonomy	.892*	.878*	.968**	.970**	.892*	.928*
Frequency	.640	.552	NA	NA	-.799	-.852
DM	.953*	.922*	.543	.563	.614	.672

* Significant at the 0.05 level. ** Significant at the 0.01 level.

8.5 Discussion on the comparative study of the relationship between DM and DI in Mumbai, Ahmedabad and Tokyo

The absolute values of DM and DI datasets, representative of each cluster cannot be compared across the 3 cities because they are only meant for inter-ward comparison within each city. However, the **trends** identified from the regression analysis concerning which DMs

have positive effect and which have negative effect on DI, can be compared. These comparisons can be used to prescribe development guidelines for planning for optimum densities which will bring about increased human security. Table 8.9 presents the regression equations derived from each city and specifies the kind of effect; positive or negative; each DM was found to have on DI in each city.

Table 8. 9 DM trends corresponding to higher DI in Study Areas

	Mumbai	**Ahmedabad**	**Tokyo**
Regression Equation	DI = 0.239 + 0.403 Amenity + 0.383 Autonomy + 0.166 Frequency – 0.314 Physical Density	DI = 0 .474 + 0.286 Autonomy + 0.062 Amenity – 0.071 Physical Density	DI = 0.506 + 0.315 Physical Density – 0.208 Intensity + 0.286 Autonomy – 0.23 Frequency
Physical Density	Negative	Negative	Positive
Intensity	NA	NA	Negative
Amenity	Positive	Positive	NA
Autonomy	Positive	Positive	Positive
Frequency	Positive	NA	Negative

From Table 8.9 it can be concluded that the DM trends that correspond to better Human Security are:

1. Higher autonomy in all three cities.
2. Lower Physical Density and higher Autonomy in the Indian cities.
3. Higher Physical Density corresponds to better Human Security in Tokyo. Amenity has no significant effect.
4. Low Intensity and low Frequency areas (these are also the areas of high Physical Density) correspond to better Human Security in Tokyo.

8.5.1 Understanding the composition of Physical Density

It has been established that the value for physical density is in some cases too high and in some cases too low and may lead to intensification of inequalities in DI.

In the case of urban areas in developing countries, high physical density was associated with slum areas which had low amenity and autonomy and very high built intensity (BUA). This implies that crowding for a limited supply of jobs, amenities and open spaces intensify the socio-economic insecurities of the people living in such conditions in these cities. In the case of Tokyo, an urban area in a developed country, areas of low physical density was associated with low DI. These areas had low residential density and building intensity as high value inner city areas were occupied by the commercial sector. The frequency density of these areas was also

therefore very high owing to the large differences in daytime and nighttime densities, which encouraged a high level of pollution as well as crime as is typical of such areas. Areas of high DI were those where affordable housing could be found close to suitable jobs, and hence were the areas of high residential density and high amenity.

The value of physical density must therefore reciprocate the values of the other DM datasets.

A methodology for analyzing the relative crowding of density measures has been discussed in this research and demonstrated through three study areas, where it has been successful in identifying the urban typology that corresponds to lower DI levels by intensifying existing socio-economic problems.

This section explores the meaning of physical density being “too high” and “too low” in order to understand the balance of DMs to be achieved for optimality.

1. The FAR of urban areas is usually fixed by development guidelines. FAR is the product of BUA and number of floors. The BUA is the % of plot area that is built up, i.e., it represents the building footprint area as a percentage of the total plot area and has been used to assess the **intensity density** in this research. It is therefore a good indicator of open space availability. In the micro level mesh analysis, it was found that HIG and MIG housing (high DI) largely correspond to BUA of 30% or less. This percentage increases with MIG housing, rising to an average of 50% and in slums it is seen to be above 60%. In squatter settlements, which have the worst DI, BUA is generally close to 100% (Fig. 8.14). It can therefore be said that in the case of Mumbai, BUA increases with decrease in DI.
2. In the case of floors, the micro-level analysis showed that HIG and MIG housing correspond to higher floor heights, usually of 8 floors to 20 floors. The LIG corresponds to 4 to 8 floors, whereas the slums and squatters are generally 2 and 1 floors respectively. It can therefore be said that in the case of Mumbai, floors increase with increase in DI. (Fig. 8.14)
3. As density is calculated per sq. km., the plot area for development available in 1 sq. km. is the area left over after subtracting the space needed for circulation and city level amenities. Different cities will have different shares of total urban space dedicated to transportation and other infrastructure. The pattern of road layouts, the historical evolution of the city, the type of public transport used and a host of other factors will affect this. This factor which expresses the land for development is termed the plot factor (Patel, 2012). If an average of 30% of urban land is dedicated for such purposes, then the plot area available for development in each sq.km., can be found by multiplying 70% x 1 sq. km. = 0.7 sq. km. = 700,000 sq. m.

4. Multiplying the FAR found in (2) with plot area per sq. km found in (3), will equal the total built up floor space. If the residential BUA of the area is known, then the total residential built up floor space can be calculated.

So,
$$Residential\ floor\ space\ per\ sq.km. = Residential\ BUA\ \times\ floors\ \times\ plot\ factor \times 1\ sq.km. \quad \text{---------- vii}$$

5. Dividing the total residential built up floor space found in (4) by the average size of tenement will give the number of tenements present per sq. km. The average size of tenement is dependent on the economic status of the household and real estate price in the area.
6. Each tenement is shared by the number of people equal to the average family size. Therefore, multiplying the number of tenements per sq. km. by the average family size will give the total number of people residing per sq. km., which is also the **physical density of the area. This is also the maximum number of people that can be housed per sq.km.**

$$Physical\ Density\ per\ sq.km\ = \frac{BUA_R \times Floors_R \times PF_R \times HHSize \times 1000000}{Residential\ tenement\ size}$$

Equation 8. 3 Composition of Physical Density

7. If the actual physical density is more than that calculated by the equation, then the actual resident population is greater than the housing capacity. This indicates the presence of informal housing. The upper limit of Physical Density at the micro level (1 sq.km.) can therefore be determined by this equation.

In order to find ideal density for Mumbai, the ideal space allocation for residential space, income space, social amenity space, and the determination of ideal plot factor and ideal FSI has to be done. It is impractical to suppose that absolute ideal values for each of these quantities exist. Income space for example will vary for each different type of occupation. Residential space can be greatly enhanced by the amenities present within the house, the space design, as well as quality of built structure, which is why there cannot exist a specific ideal residential space either.

The methodology proposed in this research can be replicated in other cities to assess the DM layers that need to be targeted for structured planning interventions. It is suggested that identifying such shortfalls and taking steps to amend them should be a first step in the development process as targeting DI issues would otherwise be in vain.

8.5.2 Achieving Optimum Densities for increased Human Security in Clusters 1 and 2 in Indian Cities and Cluster 5 in Tokyo

Cluster 1 & 2 in Mumbai and Ahmedabad were characterized by existing low physical density, high autonomy, high amenity and high frequency. Similar characteristics are seen for cluster 5 in Tokyo which is characterized by existing low physical density, high autonomy, high amenity and high frequency.

These areas have the risk of losing too much residential density and be occupied with a majority of commercial uses. This has shown a high level of crime and pollution in Tokyo. However, in order to increase physical density, affordable housing is needed. These areas have very high land value and so building affordable housing within these wards may not be financially feasible for the local authority.

The residential density of these areas can be increased by:

- Group Housing projects / institutional housing projects such as dormitories and studio apartments, which have very small unit size and so can achieve high density within small plots of land.
- It is important to increase the connectivity between various DM elements so that greater access to these may be achieved in smaller land spaces.
- Highly mixed land planning is needed, with mixes across uses (residential, commercial, industrial, public, etc.) across socio-economic classes, and across scales. This will increase interaction between people and increase the eyes on the road, which will reduce crime.
- Restrictions for private vehicles and encouraging the use of public transport and pedestrians will reduce pollution and further increase the eyes on the road.
- The group housing projects will attract businesses such as shops, cafes, newspaper stands, etc. These should be encouraged and suitably planned.

8.5.3 Achieving Optimum Densities for increased Human Security in Clusters 4 and 5 in Indian Cities

The function explained in Equation 8.3 can be of great help when planning development policies for specific neighbourhoods where the socio-economic profiles of the residents is similar, and generalised assumptions of amount of space used for its various functions can be made. This can then help to check if the development policy being proposed brings about drastic changes that will compromise the space requirements leading to excessively high density, or if it will lead to excessively low density.

Application of Results to Plan for Optimum Density for Dharavi

To illustrate the applicability of Equation 8.3, the existing and proposed conditions of Dharavi under the SRS scheme described in chapter 5 are discussed. High physical density and low autonomy, as well as low amenity are the typical characteristics of this low DI area.

The calculation of physical density, considering the spatial aspects of amenity, and autonomy, has been discussed in Equation 8.4 below. A similar equation has previously been suggested by Shirish Patel, working on the density issues in Mumbai. However, by including the dimensions of all the density measures, this equation can be applied to calculate ideal density for areas as well as predict the density values of areas as shown in Table 8.15.

The built character of Dharavi is uniform in terms of residential and income spaces. So it can be stated that,

$$Physical\ Density\ per\ sq.km\ = \frac{BUA \times Floors \times PF \times HHSize \times 1000000}{Tenement\ size + Income\ Space + Amenity\ Space}$$

Equation 8. 4 Composition of Physical Density of Dharavi

The BUA of this area is very high; >60% on an average. The average number of floors is 2. The average tenement size is hard to define; however, they are either equal to or larger than the standard 25sq.m. stipulated for the rehabilitation tenements. These house families of an average household size of 5. The slum also has an extensive industrial base which employs a large part of the slum population in the informal industry. The average workspace per person can be estimated to be approximately 2-10 sq.m., which will vary with the type of work. The amount of space dedicated to laying down amenities, for circulation, for social activities and for open areas, is very low. The equation 8.4 can therefore be used to calculate the existing density of Dharavi (Table 8.10)

Table 8. 10 Existing, Proposed and Ideal density for Dharavi

DI Type	BUA	Floors	PF	HH Size	Residential Space	Income Space (Autonomy)	Social Amenity Space	Physical Density
Dharavi Existing	0.7	2	0.9	5	25	5	0	210,000
Dharavi Proposed	0.2	15	0.6	5	25	0	0	360,000
Dharavi Ideal	0.5	5	0.7	5	25	10	5	218,750

The rehabilitation scheme seeks to rehabilitate the existing population in one third of the plot area. It proposes to improve amenities and circulation. However, it does not provide space

for the operations of the informal industry. Using the equation 8.4, the physical density of this proposal can be estimated and it is seen to be astronomically higher than the previous density (360,000 persons/sq.km compared to the previous 210,000 persons/sq.km). In addition this proposal will have no space allotted for the income and amenity of the slum dwellers resulting in perceived failure of the project.

The slum networking approach used in Ahmedabad that works towards the provision of amenity and tenure, and lets the slum upgrade itself from the investments of the slum dwellers themselves, would be a much more sustainable solution. Also, the financing schemes being used in Ahmedabad to support the informal sector, would radically change the autonomy DM of slum areas. Although the autonomy of these areas is very small, the inhabitants in these areas are all earners. Their employment is not counted in autonomy calculation because they belong to the informal sector. Instead of not recognizing these informal establishments in the proposal, if they were strengthened, then the vulnerability of the slum dwellers would be reduced drastically which would reap huge benefits for the individuals, the community, the city, and may be the only solution for creating slum-less cities. The equation 8.4 is therefore used once again, this time with allowances for income space and amenity space of the slum dwellers, to demonstrate that rehabilitation can be done at a density of 218,750 persons/sq.km, using the entire slum area, and implementing a 0.5 % BUA regulation.

The Cluster 4 and 5 in Mumbai and Ahmedabad were characterized by existing high physical density, low autonomy and low amenity. Some planning actions are listed below which may be applied to improve the Human Security of these areas by increasing the Amenity, Autonomy and reducing the Physical Density of these areas:

1. Increase Amenity

1st STAGE - BASIC AMENITY

- Water Supply – 100% coverage – 180 LPCD
- Sewerage 100% coverage
- Electricity
- Health Clinics and Maternity cells
- Improve quality of schools and increase capacity
- Parks and open spaces

2nd STAGE - OTHER AMENITIES

- Vocational Training centres

- Pedestrian Infrastructure
- Banks, small shops, gymnasium, community centre
- Indigenous markets, hawking areas, farmer's markets, repair shops
- Religious buildings
- Night shelters
- Library
- Public plaza
- Support system for self-help groups
- Instil civic pride through design features and street festivals
- Create recreational amenities for the mutual enjoyment of all socio-economic classes
- Improve healthcare – quality and capacity
- Carry out disaster drills, city cleaning drills, and firefighting drills
- Improve pedestrian infrastructure

2. Increase Autonomy

- Identify MSMSEs and provide incentives for cluster development such as:
    - Designate areas for workshops and retail spaces for MSMEs
    - Innovative taxation – making these occupations legal
    - Provide cluster benefits such as good connectivity, and encourage indigenous markets
- Slum rehabilitation practices must be made more sensitive to the local autonomy. The rehabilitated structures must retain the physical spaces and social interactions that facilitate the industries in slums. This should be governed by legislation

3. Decrease Physical Density

- Identify adjoining areas of development potential, which have low physical density, low amenity and low autonomy
- Invest in attracting secondary sector and tertiary sector job providers to these areas by the provision of amenities and development incentives
- Also, undertake affordable public housing projects in the areas using PPP model, as well as rental housing projects
- These interventions will attract people from the high density areas of clusters 4 and 5

8.5.4 Framework for Implementation of Proposed Methodology

The steps of the statistical analysis described in chapter 4 of this thesis, are shown in Fig 8.24. The first two steps of this methodological framework can be applied to assess the DMs of any city as demonstrated in this thesis. These steps will help to understand which of the DMs are strongly related to the DI of the city wards and ascertain which DM have a positive relationship and which have a negative relationship with DI.

The third step of this methodological framework can be applied to assess the areas within the city that have low DI. This can help to identify the most vulnerable wards which may be selected for micro-level analysis.

Using the regression analysis in step 2 and looking at the trends of DM data corresponding to each DI cluster identified in step 3, an analysis of the crowding factors of the city can be done. As shown in the analysis of each study area, DM datasets that had a correlation coefficient greater than 0.5 with the clusters defined by composite DI, and were significant at the 0.05 level (95% confidence level), were plotted to notice typical DM trends of each cluster.

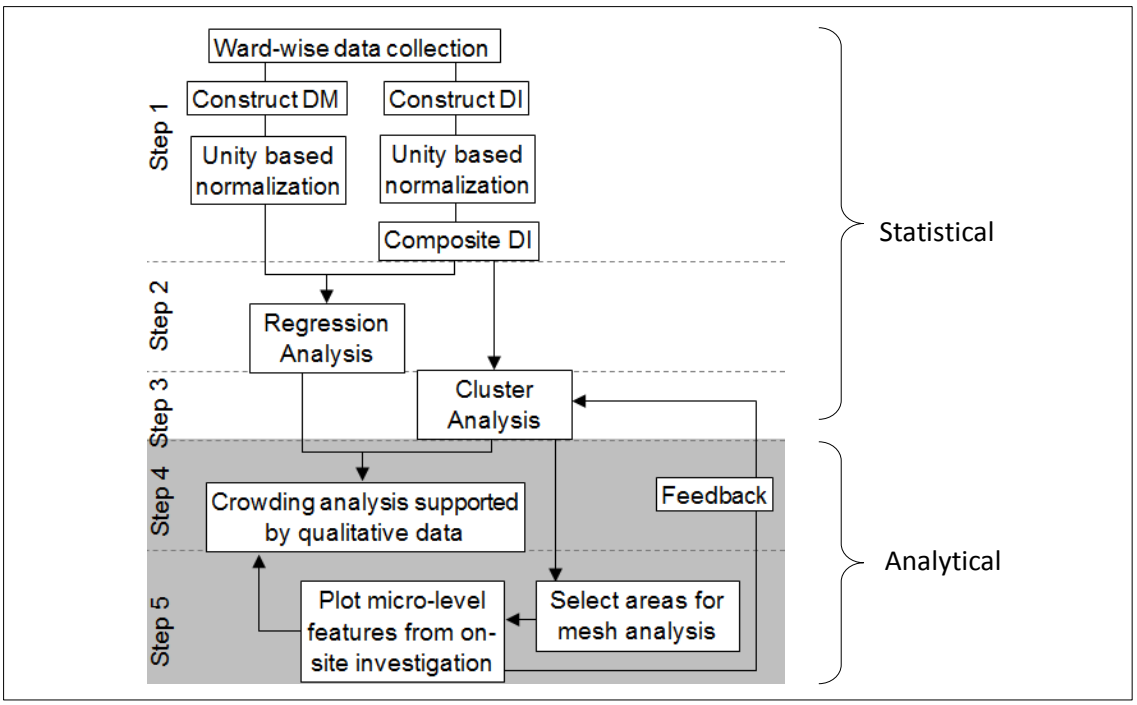


Fig. 8. 24 Methodological Framework for analysing case studies

The crowding situation of the worst DI clusters was implicit from the observation of these trends. Since the areas of low DI can be found from step 3 and the crowding factors of these areas can be found from step 2, these areas can be targeted and the crowded DMs in these areas resolved through planning interventions.

The crowded DMs that intensify the existing stresses within the urban system can be identified as detailed in the previous section. However, in order to eliminate insecurities of certain socio-economic groups, it is necessary to address the issues of DI directly. The DI datasets that had a correlation coefficient greater than 0.5 with the clusters defined by composite DI, and was significant at the 0.05 level (95% confidence level), was plotted to notice typical DI trends of each cluster. The socio-economic issues specific to each urban area and the characteristics of the marginalized communities could be identified from this analysis. The spatial distribution of such marginalized communities is also identified by mapping the results of the cluster analysis (by plotting cluster association of each ward). Thus, the sectors for development and the areas for the same are both known.

The socio-economic profiles of the vulnerable communities are identified as described above. These **communities** must be included in the development process to bring about sustained development. The participation of these communities must be encouraged at all stages of the development, from problem identification, prioritizing, project phasing, proposal formulation, financial mechanism, and implementation. In addition to the local community, it is also important to involve the **private sector**, which will include corporate sponsors, academic institutions and research cells, local planning consultants working in the area, as well as national and international banks and financial institutions. Mobilizing the local community is an intensive process that requires one-to-one interaction and understanding the community at the grassroots level. **Non-government organizations** (NGOs), community based organizations (CBOs), and volunteer organizations are very effective in such activities. The participation of these organizations is therefore crucial in every stage of the project. The activities of all of these participants must be given statutory backing by the local and municipal **governments**. The urban planning works are also sometimes carried out by the planning division of the municipality; however, this could also be delegated to private consultants and/or academic institutions. The legal framework containing the exact roles of each of the stakeholders involved, is very important to maintain transparency, ensure the best interests of the community and the urban area, as well as a prerequisite for the success of the project to be adapted and replicated over various parts of the urban area.

The steps 4 and 5 of the methodological framework shown in Fig. 8.24 which involve the qualitative analysis of the vulnerable areas identified in step 3, by mesh analysis and literature reading and field visits, is necessary for the formulation of development policies aimed at improving DI levels. The mesh analysis will help to identify exact urban typologies associated with socio-economic vulnerability, and help to identify vulnerable neighbourhoods in the mesh

of 500m x 500m. The field visit and literature reading will help to build up the informed knowledge about the specific urban area and the stakeholders. A study of the historical evolution of the urban form from the perspective of urban evolution, economic evolution and socio-economic changes, is a necessary prerequisite to understand the context. This will be further strengthened by local experiences of the local actors (Government, NGOs, community and private sector) carrying out the analysis.

The two step process through which the methodological framework proposed in this research can be put to practical use, which has been discussed in this section (8.5), is illustrated in Fig. 8.25.

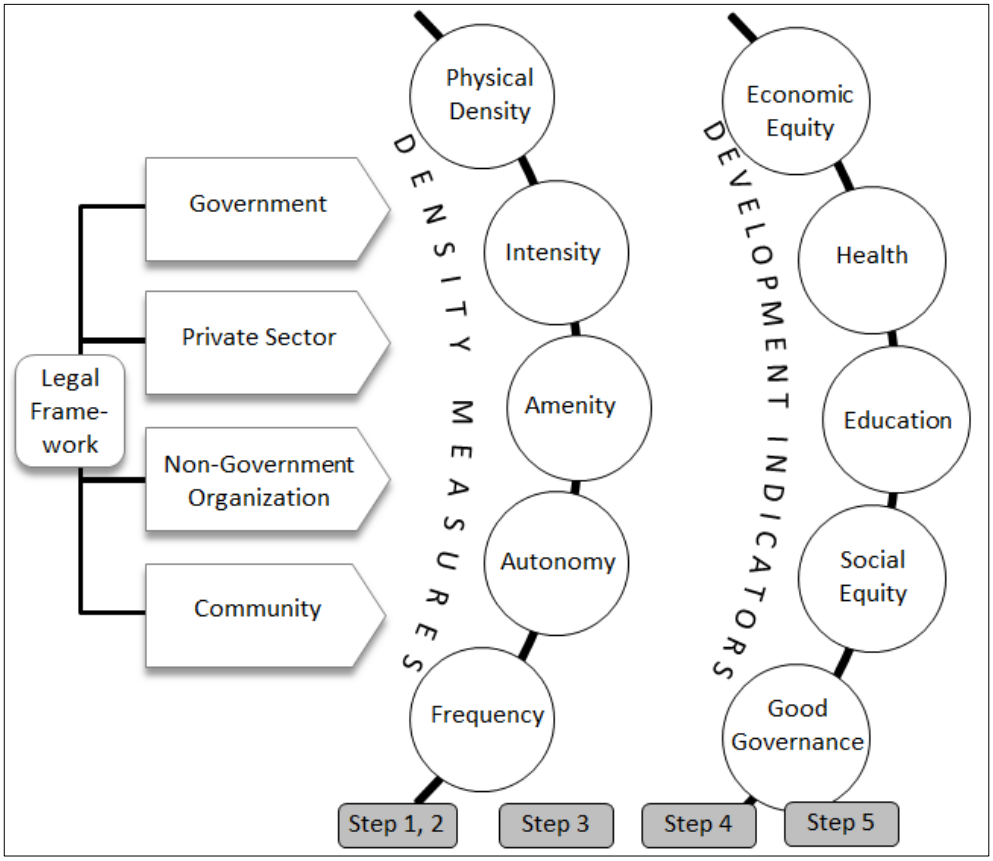


Fig. 8. 25 Structure for the practical application of the methodological framework proposed in this research

8.6 Conclusion

A discussion of the statistical analyses applied to the study areas has been presented in this chapter. The mesh analysis has successfully confirmed the results of the statistical analyses by supporting the hypothesis that stated the existence of an intrinsic relationship between DMs and DIs in urban areas.

The exponential density function and inverse power functions have been applied to model the density measures in each of the cities with moderate success. These functions have been able to give accurate predicted values of the Density Measures that were found to have a strong relationship with DI in each city. The DMs have been modelled according to the levels of DI within spatial clusters in each city.

A framework for prioritizing the baseline attainment of DMs has been proposed as a foundation for structured development plans targeting the DIs. **The 6th and final objective of the research has therefore been achieved.**

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Chapter 9:

CONCLUSIONS AND WAY FORWARD

"By far the greatest and most admirable form of wisdom is that needed to plan and beautify cities and human communities."

- *Socrates*

9.1 Achievement of Research Objectives

Six objectives had been laid down in the first chapter of this thesis which formed the basic structure for the method of enquiry of this research. This section elaborates the extent to which these objectives have been achieved, their implications for urban planning practice, as well as their limitations.

The objectives of this research were:

1. To formulate indicators to measure levels of Urban Density (Density Measures).
2. To formulate measures for Urban Development (Development Indicators).
3. To apply these measures to cities and adapt them according to data availability and the historical, economic, political and social context of the city.
4. To derive substantial relationships from ward wise comparisons between levels of Human Security and measures of Urban Density and identify the elements of crowding in each city.
5. To identify ward clusters of differential human security levels.
6. To model urban density according to human security to serve as a tool for urban planning.

The overall aim of this research was, to formulate a methodology for assessing the Urban Density layers of cities corresponding to various levels of Human Security and to use this methodology to make Human Security a priority for planning better urban areas. Each of the objectives stated above are progressive steps for the realization of this overall aim. The achievement of each objective also offers individual applicability to urban planning practices. These individual applications, the contribution in formulating the methodological framework which is the overall aim, and applicability of this methodological framework, are discussed in this chapter.

The achievements of the objectives are discussed in the following section.

9.1.1 To formulate indicators to measure levels of Urban Density (Density Measures)

Density measures were framed to quantify the access to urban resources and systems for residential, economic and social pursuits. The density measures used widely available ward level datasets to calculate the density of various urban resources and systems. The layers of the DM were, Physical Density, Intensity, Amenity, Autonomy and Frequency, which measure the density of residential occupation of urban land, density of built up structures (as opposed to open spaces) on urban land, density of urban amenities serving urban residents, density of

formal modes of income available for urban residents, and the daytime floating density of urban areas respectively.

The DMs represent the basic elements; the resources, in an urban system. These elements are affected by various relations within the urban area; such as land rent, production-consumption zones, major O-D points, topographical, geographical and historical relations, etc. The various socio-economic groups residing in the city have differential access to the elements. These differences arise due to the restrictions posed by their socio-economic profiles in interaction with the urban relations. The way in which urban households are able to access urban elements for residential, economic, and social pursuits, decides the daily system of each household. Households in similar socio-economic communities have similar systems which overlap spatially, giving rise to the social areas of the city. The DMs allow for the understanding of the relative access to urban elements of residents across the various wards of the city.

9.1.2 To formulate measures for Urban Development (Development Indicators)

Development Indicators have been framed and calculated for the case study cities using ward level census data and adapted for the specific insecurities of the different urban contexts. The measure of the DI help to understand the levels of economic equity, health, education, social equity, environmental quality and governance of the wards of each city studied.

Measures of human security (DI) have been developed centred around the capability approach. Enhancing the capabilities of people of all socio-economic backgrounds residing in the urban area forms the priority of this thesis. Increased crowding for urban resources increases their cost, as demand outstrips supply which causes a disparity, since only the higher socio-economic classes can have access to them and the lower socio-economic classes are deprived. The aim therefore is to reduce the gap between the highest DI and lowest DI, so all wards have a decent level of human security. It is important to know the crowded aspects of a city in order to reduce this disparity.

The Development Indicators measure the capability of residents of each ward to carry out basic functions and maintain a standard of living deemed suitable by them, in relation to the socio-economic culture of the city. This is a very important measure for urban planning practices since it has deep implications on a number of issues in discussion by the planning community. Firstly, higher capabilities increase the economic and social capital of communities, making them more resilient towards unexpected shocks caused by economic downturns, political unrest, natural hazards, and increase their preparedness to minimize damages and the capability to cope with and recover from such shocks. Secondly, higher capabilities also translate into higher economic and social equity between genders. The empowerment of

women has been proven to have strong positive trickle down effects on vulnerable communities, in terms of increase in health and nutrition quality, better family planning, higher sanitary standards, higher school enrolment rates, and stronger finances at household and community level. The measure of DI therefore identifies the areas in a city which need urgent intervention to increase DI levels. The DI also provides a guideline for which sectors need to be strengthened. Planning practices aimed at increasing DI, as an urban planning approach, is comprehensive and provides long lasting results for sustainable urban communities.

9.1.3 To apply these measures to cities and adapt them according to data availability and the historical, economic, political and social context of the city

The spatial, economic, political and social evolution of each case study city has been studied in detail to understand their urbanization. This has helped to understand the issues being faced by the residents of each city and construct contextual linkages of these issues to the city's urban history.

The concept of "Relative Poverty" discussed by Adam Smith which has been incorporated in Amartya Sen's research on relative capabilities, stresses on the importance of understanding socio-economic issues within the local context. It is however, very difficult to define rigid boundaries due to the dense web of global connections that characterize modern urban areas. Defining a set of standards describing the ideal standard of living becomes even more difficult with increasing inequalities. The lifestyles of the wealthiest of Mumbai's elite are enviable in any part of the globe, whereas, the poorest live in unimaginable poverty, lacking basic amenities such as food, water and sanitation.

The DIs and DMs therefore do not measure the relative deviation from any ideal value. Indeed, no absolute optimum value of DI and DM can exist. Instead, the core wards of each city have been studied, which have a shared urban past and are the most resource rich system with highest financial and social capital. The debilitating issues in these areas have been considered while constructing the DIs, to quantify these relative insecurities and measure the level of inequality between the "best" and "worst" wards. The same DMs have been applied in all the cities to understand how the relative insecurities expressed by DIs are related to DMs. The "Step 1" of the methodological framework formulated addresses this objective (Fig. 9.1)

9.1.4 To derive substantial relationships from ward wise comparisons between levels of Human Security and measures of Urban Density and identify the elements of crowding in each city

A methodology for statistical analysis was formulated and applied to each of the study areas to investigate the relationships between DM and DI in each city. The "Step 2" of the overall methodological framework was applied for this purpose (Fig. 9.1). It involved various data mining techniques including multiple regression analysis and has resulted in the identification of the DMs that are associated positively and negatively with DI in each city. This has proved that a relationship between DM and DI does exist as hypothesized and also identified the DMs that are crowded in the low DI wards in the study areas. Specific sector based planning interventions can therefore be framed based on improving the levels of these overcrowded elements.

9.1.5 To identify ward clusters of differential human security levels

The step 3 of the methodology (Fig. 9.1) involving the cluster analysis has helped to identify the ward clusters in each city that have the lowest human security, as well as the specific DI levels of each ward. The city is divided into 5 clusters of DI representing 5 different levels of capabilities, from very high, high, average, low and very low. This can be effectively applied to framing structured planning policies catering specifically to the DI levels of each of the 5 different clusters.

The 4th step in the methodology (Fig. 9.1) involves qualitative analysis of urban areas to understand the trends shown by steps 2 and 3. Literature study on the crowded elements identified has revealed explicit understanding of the relative access to these urban resources. Additionally, the wards that belong to the worst DI clusters have been investigated in greater detail. Parallel studies such as the "Mumbai Human Development Report 2009" and the "Social Atlas of Tokyo" have confirmed the results found in the cluster analysis. Furthermore, the cluster-wise trends in various datasets that were very highly correlated with the DM and DI respectively have been plotted. This has revealed the salient characteristics of various social areas of the cities studied. The exact implication of the relationship between DM and DI has hence been understood and typical urban typologies of various levels of DI in each have been identified.

The 5th and final step in the methodological framework (Fig. 9.1) involves the micro-level mesh analysis which, applied to three wards in Mumbai, has definitively supported the results of the aforementioned regression analysis in establishing that a relationship between the DM and DI does indeed exist. It has investigated the relationship between intensity datasets (Built

up area, and number of floors) and housing grade. As a result, typical urban typologies that correspond to a range of different socio-economic levels have been identified. The identification of these urban typologies can find wide application in the assessment of quality of urban areas and neighbourhood level planning initiatives though a framework targeted at improving DM and DI levels.

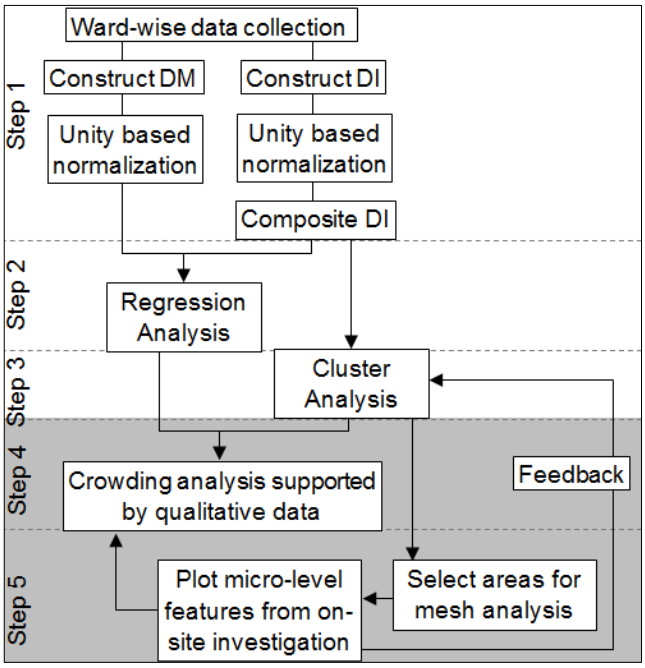


Fig. 9. 1 Methodological Framework

9.1.6 To model Urban Density according to Human Security to serve as a tool for Urban Planning

Different DM affected DI in different cities. The DM could be modelled using the negative exponential function and inverse power function in each city. The Pearson's correlation coefficient found for all the predicted DM results was high ($r > 0.5$). However, not all of the coefficients were significant (p-value < 0.05 is taken as significant). This may have been due to the very small dataset and in the absence of more significant results no universal conclusion can be stated. It may however be assumed that the DM, especially those that had shown a strong relationship with DI in the regression analysis, can be predicted by the negative exponential and inverse power functions across all wards in each city.

The modelling of DM based on DI gradient using standard mathematical models has several possible applications in Urban Planning. Firstly, the modelling of DM levels based on DI can help to identify the areas where various DM elements are crowded, as well as the specific elements which are crowded. This can help to formulate area specific and sector specific

planning interventions to affect DM so that the DI of that area is improved. Secondly, and perhaps more significantly, the impact analysis of various planning policies can be done to understand their implications before implementation. For example, a slum rehabilitation plan that promises the increase in amenity provision of the area as well as provision of free housing units to low income households seems like a positive development for the city and one which will affect an increase in DI. However, closer observation has revealed that such plans cause a huge increase in the physical density of the area and a drastic loss of autonomy for the slum dwellers. The overall effect to DI is therefore negative and the local community does not stand to benefit. In comparison, a 'sites and services' approach which allows the community to retain their economic activities and involves them in the rehabilitation process, will affect an increase in DI in the area.

These objectives have been achieved using data from one specific year to measure multiple dimensions of urban density and human security. Periodic application of the methodology proposed will help to apply a planning approach centred on human security.

9.2 Results of Analysis of Case Studies

DM profiles corresponding to low and high DI levels have been identified in each city studied. These profiles are discussed below:

It was found in the case of Mumbai and Ahmedabad; the cities of a developing economy, that the struggle to have access to basic necessities takes central place in people's lives, hence depriving them of striving for and achieving higher goals of education, participation in local governance, and equality in the socio-cultural system. However, comparing the absolute values of the DI datasets, we see that Ahmedabad was much better off than Mumbai.

Slum areas have physical density values as high as 10 times that of non-slum areas. The wards with high number of slums therefore have higher average physical densities, which explain the negative relationship of physical density with DI. The results of the mesh analysis also show that lower built up percentages and higher number of floors correspond to better housing grades across all three wards. So, higher and middle income groups residences correspond to mid to high rise buildings with less ground coverage and more open space area whereas slums have very little open space and are mostly low rise.

High cost of housing is a major problem in Tokyo which has forced a majority of the working population to find residences at very far distances from their working places within the city. This has caused the floating population of the city to be very high. Also, the high land price has caused high intensity development and the depletion of open areas. Following the land rent

theory, commercial and office uses occupy the central city, with very low residential density, high floating daytime density and high building intensity, which lead to high pollution during office hours and high crime after office hours. The areas which have high residential density with sufficient employment in the vicinity do not suffer from the aforementioned problems and are therefore the areas of high DI.

9.3 A Framework for Planning Approach based on Human Security

The framework followed in this research is shown in the flowchart in Fig. 9.2.

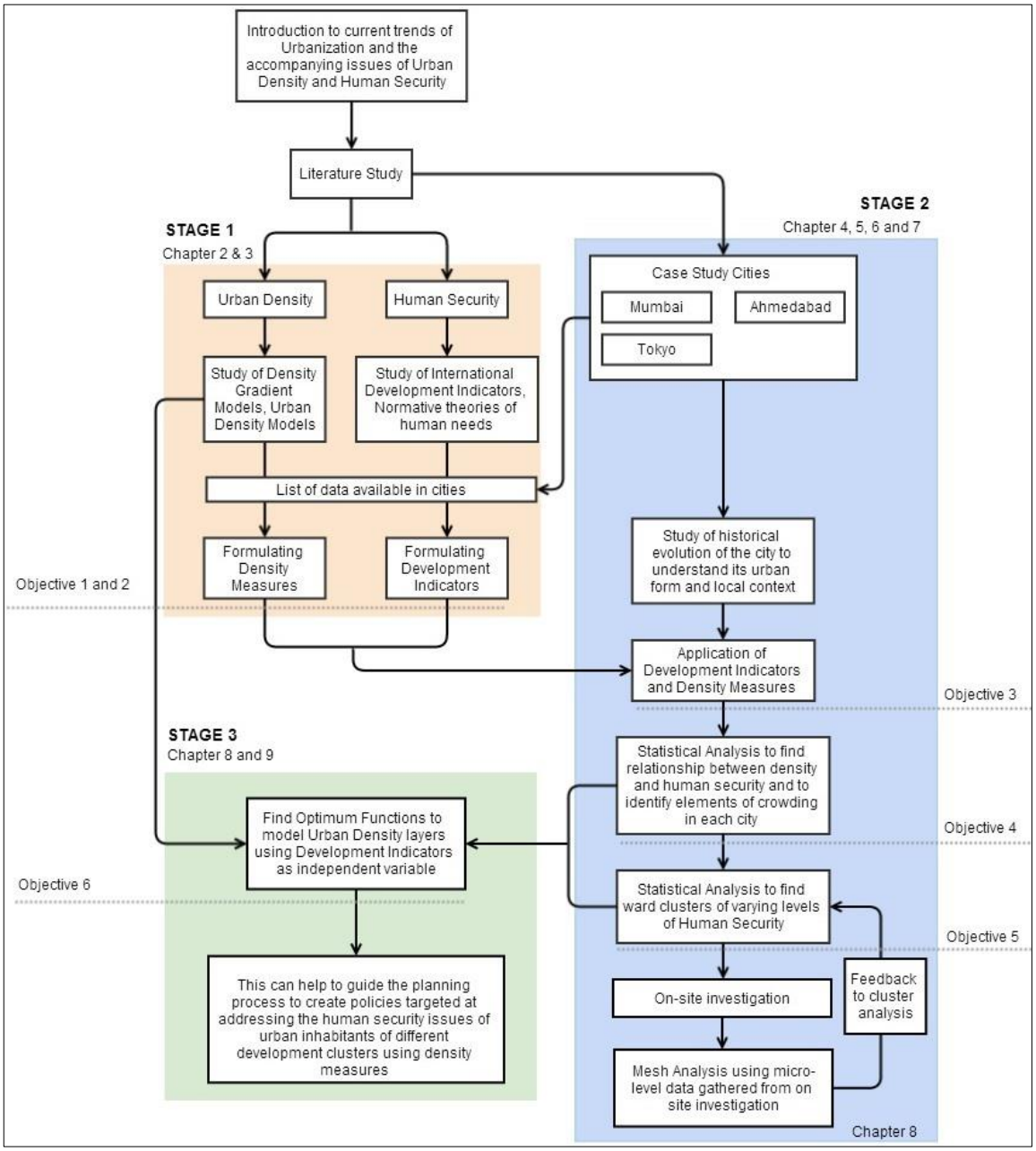


Fig. 9. 2 Framework of Research

The study of the 3 cities and the density related planning policies practiced in these cities suggest that for the policies to give sustainable results, a minimum threshold level of density measures is required as a baseline to prevent crowding. Actual development in human security can then be brought about by framing policies targeting the improvement of the DI measures. This methodology can be used to formulate specific development proposals for small areas, as their specific issues of crowding and human security can be evaluated and prioritized. A legal framework involving multiple stakeholders will bring efficiency to the process, help in reliability and ensure accountability. It is imperative to involve the local residents for development interventions to be effective over a long time. A framework for a planning approach based on this research is shown in Fig. 9.3.

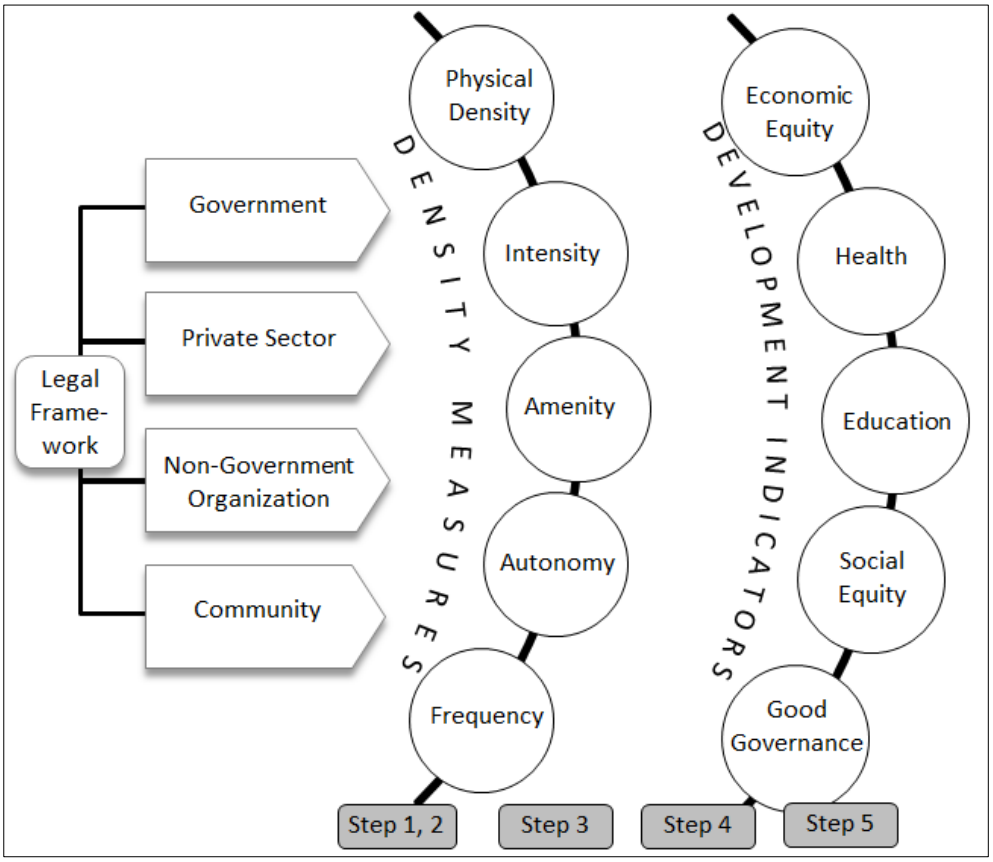


Fig. 9. 3 Framework for Planning Approach based on Human Security

9.4 Way Forward

As the megacities of the developed world continue to shift from a service based industry to a greater focus on administrative control of world companies, as well as knowledge based and creative industries, a greater share of urban residents in developing countries are finding employment in the back offices of global businesses. Local and national governance machineries in these developing countries are aggressively building infrastructure and providing

tax incentives to woo foreign companies to invest in their regions, enabling the development of urban areas which are the engines of growth for the respective nations. The increase in primacy of urban areas over their rural hinterland is affecting an increase in the cost of housing. The government is incapable of providing affordable housing and optimum capacity of basic infrastructure to keep up with the rapid growth in population. Real estate companies are benefiting from this huge housing demand, further inflating housing costs. A large portion of urban populations in developing countries are therefore unable to afford suitable residences and are forced to squat illegally.

The creation of millions of such jobs is therefore a double edged sword. Fuelling the economic development on one hand, they also account for rising inequality between the socio-economic classes in the megacities of developing countries on the other. These inequalities have been explored in this dissertation. Based on the concept of the capability approach, this research has proposed a new urban design method to identify the appropriate urban density layers which have a profound relationship with the quality of life from the viewpoint of human security.

In the quest for an urban planning approach centred on the concept of human security, enabling the freedom from fear, freedom from want and freedom to live in dignity, the identification of issues debilitating these freedoms; the subject of this doctorate research, is the first stage. Identification of opportunities and strengths within the communities of low human security and developing these at the grassroots level as well as forming policies to integrate the strengths of various such communities in a network of city-wide production cycles feeding one another will provide lasting and empowering solutions for the urban poor and socially excluded communities. Such a model is envisioned to work in a reverse spiral manner as that of the current trend of poverty traps, and integrate the formal and informal economies, as well as bring the marginal settlements into the domain of legal housing.

An example of an opportunity presented by squatter settlements is their creativity and ingenuity among limited resources. The wealthy portions of urban population in developing countries have a large disposable income. The weaker economic sections in these cities have identified this and depend on it for their livelihoods. These sections support themselves by providing cheap labour intensive services and retail goods such as perishable items, consumer goods, and durable goods at competitive rates. A short walk through any slum settlement in Mumbai shows a host of small scale industries, manufacturing everything from kitchen appliances, car parts, traditional costumes, leather luggage, earthenware, and much more, using machinery which are prototypes of local trial and error, and using raw materials such as

melted beer cans, plastic pellets from old computer cases, and processed leather, the complete life cycle of which can be traced within the slum. These ingenious indigenous enterprises, when integrated in a city wide manner, would become a very strong contributor to the city's economy.

The role of urban areas in developing countries as back offices of global enterprises puts them at the bottom of the production pyramid. The integrated development of indigenous industries would enable them to have greater control over the creative aspect of productions as well as respond directly and effectively to local needs.

In the cities of developed countries, New Urbanism and the design of Smart Cities are the current buzzwords of Urban Planning. These approaches recommend high density mixed-use development to reduce travel distances and encourage creative economies. A strong focus on pedestrian design, streets encouraging bicycle use, design of community social spaces and streetscapes responsive to those on foot rather than for automobiles, is being encouraged. It is interesting to note that slum areas, such as Dharavi in Mumbai, possess all of these qualities. A dense labyrinth of walkways with personal decoration of residential facades forming the landmarks of visual perception and recognition, the settlement has the densest possible mix of land uses with most tenements acting as industrial units as well as homes. Its industries are connected as the by product from one is the raw material for another. Constructed entirely by the residents themselves, the patios and porches within this extremely high density settlement are a direct spatial manifestation of the socio-cultural needs and traditional habits of the people, limited by their socio-economic capabilities. It is indeed an extremely creative community as is expected from these spatial features by the hypotheses of New Urbanism. Identifying local strengths of such communities and building a network to integrate the economic pursuits, residential and social spaces, financial support, etc., will therefore not just be beneficial for developing nations, but provide workshops for creating new urban design approaches for vibrant urban communities in general. In cities where the built environment dictates the behaviour of residents, it will provide an opportunity to understand the organic urban character created when the people design and construct their environment themselves. An inquisitive interaction at the micro scale to understand and map the spatial features, social networks, flow of resources, and semiotic connections within informal urban settlements as well as their interface with the formal urban area, will help to build an integrated planning approach based on human security. This study, a multi-disciplinary research encompassing areas of Social Psychology, Development Studies, Welfare Economics, Architecture and Urban Planning, is proposed as the author's subsequent research endeavour.

Annexure

1. Mumbai Data

Datasets for Development Indicators

	Ward	Economic Equity			Health			Education					Social Equity								Good Governance			
													Gender Equity											
		% Main Employment	% Unemployed	Composite	Average life expectancy (HDR)	Child mortality (HDR 2001 data)	Composite	% Literates	Total Enrollment	Pupil teacher ratio	Out of School children	Composite	Number of females per 1000 males	Literate females per 1000 males	Working Females per 1000 males	Number of females per 1000 males of slum population	Number of female children per 1000 male children of slum population	Slum Population %	Resident Dependent %	Composite	Crime Rate (Average Total occurances/ year) Praja.org	Rank given to local elected represent-atives	Composite	Composite DI
A	Colaba	43.23	54.95	0.69	50.61	41.88	0.63	75.46	17980	33	259	0.60	733	647	212	787	952	28.88	54.95	0.62	7176.00	21	0.55	0.62
B	Sanhurst Road	38.89	60.04	0.42	53.81	36.6	0.74	75.72	8305	40	11	0.49	735	673	113	638	891	13.33	60.04	0.31	3576.00	10	0.85	0.56
C	Marine Lines	48.93	49.61	1.00	60.49	32.97	0.92	83.28	4518	38	11	0.62	587	552	87	NA	NA	0.00	49.61	0.13	6400.33	10	0.77	0.66
D	Grant Road	40.32	58.54	0.51	60.73	29.19	0.95	82.39	16881	32	15	0.75	863	801	244	740	898	9.95	58.54	0.68	6374.00	11	0.76	0.73
E	Byculla	37.31	61.10	0.35	48.42	44.53	0.56	75.03	4463	34	57	0.56	755	687	133	631	912	11.86	61.10	0.39	11368.67	7	0.69	0.51
F/S	Parel	33.62	64.52	0.15	46.41	41.5	0.54	80.13	2498	39	127	0.53	831	735	184	788	922	35.76	64.52	0.56	6606.33	14	0.70	0.49
F/N	Matunga	34.33	63.47	0.20	47.52	49.15	0.51	74.86	62405	42	375	0.59	791	671	152	731	920	58.07	63.47	0.39	10410.33	8	0.70	0.48
G/S	Elphinstone	36.95	61.17	0.34	52.48	26.62	0.77	79.12	19198	30	135	0.72	760	643	179	732	940	33.08	61.17	0.48	7884.33	18	0.59	0.58
G/N	Dadar/Plaza	35.14	62.47	0.25	53.95	34.03	0.76	75.25	41560	40	590	0.51	807	706	192	735	928	55.82	62.47	0.49	16028.33	2	0.66	0.53
H/E	Khar/Santacruz	34.88	63.01	0.23	50.19	34.06	0.67	75.97	40631	41	501	0.52	800	689	174	777	928	78.79	63.01	0.44	15906.67	20	0.33	0.44
H/W	Bandra	36.85	61.50	0.32	57.96	35	0.85	81.02	28706	38	203	0.64	894	819	278	797	941	41.06	61.50	0.79	11756.67	28	0.30	0.58
K/E	Andheri (East)	35.48	62.81	0.25	55.01	30.42	0.81	79.66	58040	42	268	0.66	837	743	204	817	933	58.30	62.81	0.60	17585.67	20	0.28	0.52
K/W	Andheri (West)	36.97	61.42	0.33	54.69	46.96	0.69	77.82	56632	38	405	0.67	847	764	231	761	934	45.11	61.42	0.64	16830.00	20	0.31	0.53
L	Kurla	33.31	64.40	0.14	45.88	31.14	0.59	73.47	69947	40	574	0.60	760	643	114	741	923	84.68	64.40	0.28	7511.67	9	0.76	0.47
ME	Chembur (East)	30.60	66.77	0.00	39.3	59.18	0.26	66.12	61632	45	1490	0.22	801	648	122	785	950	77.55	66.77	0.39	14099.00	5	0.66	0.31
MW	Chembur (West)	33.79	63.17	0.19	51.47	40.18	0.66	75.03	38363	38	151	0.60	829	698	201	790	929	68.48	63.17	0.51	9595.67	24	0.43	0.48
N	Ghatkopar	31.81	66.05	0.05	52.05	35.91	0.70	77.50	51055	35	125	0.74	855	743	156	826	917	70.21	66.05	0.49	12281.33	29	0.26	0.45
P/S	Goregaon	36.22	61.38	0.31	51.89	20.85	0.79	77.15	34453	40	151	0.58	791	687	178	707	922	48.10	61.38	0.44	6555.33	12	0.73	0.57
P/N	Malad	34.06	63.51	0.19	51.11	100.12	0.28	75.31	68643	40	245	0.67	819	702	150	775	930	63.65	63.51	0.47	21904.00	22	0.13	0.35
R/S	Kandivalli	36.28	61.68	0.30	51.28	31.05	0.72	75.94	44712	44	134	0.54	760	646	132	687	905	55.30	61.68	0.29	14342.00	12	0.52	0.47
R/N	Dahisar	35.98	62.78	0.26	49.98	27.5	0.71	78.56	27664	43	87	0.54	821	730	185	745	890	46.63	62.78	0.44	5078.00	15	0.72	0.53
R/C	Borivali	35.59	63.05	0.24	58.58	40.65	0.82	81.78	38940	40	267	0.65	892	828	226	800	889	33.75	63.05	0.64	6385.67	22	0.55	0.58
S	Bhandup	32.19	65.29	0.09	50.94	26.73	0.73	78.52	53597	38	478	0.66	822	714	169	811	915	85.83	65.29	0.43	11236.33	16	0.53	0.49
T	Mulund	34.62	63.45	0.21	56.97	42.08	0.78	81.09	26050	33	51	0.74	894	810	246	830	926	35.21	63.45	0.74	4410.67	3	0.96	0.69

	Most Desired
	Least Desired

Annexure

2. Mumbai Data

Datasets for Density Measures

Ward		Physical Measures of Urban Density					Amenity								Autonomy				Frequency		
		Person/ sq.km	Households/ sq.km	Slum population density of ward/slum pop density of dictrict	Decadal change in population/ sqkm	Composite	No. of recreation spaces/ sq.km of residential and mixed area	% of households, with access to water tap	% of Sewerage coverage of total ward	% of households, with access to electricity	% Households with telephone (HDR 2001)	ratio of total slum population to number of toilet seats	population per school	Composite	Main Workers/ sq.km in ward as compared to city	Marginal workers/ sq.km in ward as compared to city	Female workers/total workers in ward	Composite	Daily floating density	Ratio of Daytime density/ Night time density	Composite
A	Colaba	18495.35	3829.91	0.34	1403.77	0.14	8.83	87.24	91.53	90.23	41.28	398.77	5406	0.39	0.8	0.6	0.18	0.30	127192.98	6.88	0.88
B	Sanhurst Road	56253.20	10890.00	0.47	9164.40	0.46	18.00	91.64	98.00	90.98	43.15		4395	0.71	2.3	1.1	0.11	0.27	120000.00	2.13	0.51
C	Marine Lines	112734.44	22031.67	0.00	3163.33	0.60	24.28	86.43	98.00	86.79	54.40		8455	0.55	5.7	3.0	0.09	0.67	166666.67	1.48	0.61
D	Grant Road	58006.21	11989.55	0.36	-2834.39	0.27	17.88	98.17	98.00	98.86	65.17	57.50	5037	0.88	2.4	1.2	0.20	0.53	15151.52	0.26	0.06
E	Byculla	59504.73	10941.89	0.44	3987.97	0.38	13.46	90.42	98.00	90.87	37.32	159.80	5061	0.57	2.3	1.7	0.12	0.39	6756.76	0.11	0.03
F/S	Parel	43420.52	9120.33	1.33	3428.87	0.37	30.64	94.56	74.47	93.59	32.85	56.34	5741	0.68	1.5	1.6	0.16	0.43	1886.79	0.04	0.01
F/N	Matunga	43420.52	9120.33	1.33	3428.87	0.37	11.14	87.90	63.98	95.01	30.82	87.31	4298	0.54	1.5	1.6	0.14	0.37	1886.79	0.04	0.01
G/S	Elphinstone	58097.09	11908.83	1.68	1957.43	0.45	9.50	93.61	98.00	93.13	28.83	59.40	6188	0.59	2.2	2.3	0.16	0.54	3212.79	0.06	0.01
G/N	Dadar/Plaza	58097.09	11908.83	1.68	1957.43	0.45	11.15	96.49	72.68	95.69	31.81	81.87	6258	0.59	2.2	2.3	0.17	0.56	3212.79	0.06	0.01
H/E	Khar/Santacruz	43312.55	9136.65	1.93	7000.14	0.48	2.57	97.27	65.00	94.53	27.88	96.76	6754	0.49	1.6	1.5	0.16	0.40	7287.74	0.17	0.03
H/W	Bandra	43312.55	9136.65	1.93	7000.14	0.48	7.38	99.52	65.00	99.42	58.27	91.77	4165	0.76	1.6	1.5	0.22	0.56	7287.74	0.17	0.03
K/E	Andheri (East)	31803.83	6842.53	1.14	5096.88	0.33	6.46	97.90	69.83	97.39	40.16	59.01	5745	0.64	1.2	1.0	0.18	0.35	5473.68	0.17	0.03
K/W	Andheri (West)	31803.83	6842.53	1.14	5096.88	0.33	3.54	96.96	81.78	96.34	52.97	123.84	5517	0.65	1.2	1.0	0.19	0.40	5473.68	0.17	0.03
L	Kurla	57645.78	11256.59	3.35	11972.30	0.73	4.29	92.54	56.13	93.07	23.68	110.22	4745	0.46	2.0	2.4	0.11	0.42	NA	NA	NA
ME	Chembur (East)	19834.24	4013.24	1.01	4844.88	0.25	2.14	84.88	37.00	87.34	14.99	87.47	6367	0.20	0.7	1.0	0.12	0.19	NA	NA	NA
MW	Chembur (West)	19834.24	4013.24	1.01	4844.88	0.25	4.92	96.07	48.50	96.71	32.36	82.03	4601	0.57	0.7	1.0	0.18	0.34	455.37	0.02	0.00
N	Ghatkopar	11183.32	2332.64	1.14	4293.31	0.21	3.57	97.34	54.16	96.89	31.74	77.95	5078	0.57	0.4	0.4	0.14	0.16	NA	NA	NA
P/S	Goregaon	19232.10	4139.92	0.77	4382.57	0.23	3.49	93.30	48.15	93.07	37.91	86.56	5473	0.48	0.7	0.8	0.16	0.27	NA	NA	NA
P/N	Malad	19232.10	4139.92	0.77	4382.57	0.23	7.08	93.27	42.88	92.96	31.22	86.03	5056	0.47	0.7	0.8	0.14	0.23	1555.21	0.08	0.01
R/S	Kandivalli	18901.95	4248.99	0.59	6598.45	0.25	5.55	90.93	53.24	91.63	32.36	92.99	6275	0.41	0.7	0.5	0.13	0.15	NA	NA	NA
R/N	Dahisar	18901.95	4248.99	0.59	6598.45	0.25	8.35	93.25	66.16	89.92	40.68	62.99	5775	0.51	0.7	0.5	0.16	0.24	3865.98	0.20	0.02
R/C	Borivali	18901.95	4248.99	0.59	6598.45	0.25	9.08	94.72	53.69	94.63	54.15	61.45	5235	0.61	0.7	0.5	0.19	0.31	NA	NA	NA
S	Bhandup	11183.32	2332.64	1.39	4245.49	0.23	4.22	98.05	61.92	98.12	27.65	56.31	4800	0.62	0.0	0.0	0.15	0.11	2050.58	0.18	0.02
T	Mulund	9488.36	2113.22	0.23	1178.53	0.08	4.31	97.73	71.22	96.82	51.62	64.12	3931	0.72	0.3	0.3	0.20	0.29	862.07	0.09	0.01

	Highest
	Lowest

Annexure

3. Ahmedabad Data

Datasets for Development Indicators

	Ward	Economic Equity				Health		Education		Social Equity				Composite DI
										Gender Equity				
		Slum Household %	Slum Population %	% Unemployed	Composite	Govt. Health Facility	Composite	% Literates	Composite	Number of females per 1000 males	Literate females per 1000 males	Working Females per 1000 males	Composite	
1	Khadia	26.08	0.00	66.50	0.87	3	0.50	92.02	0.98	911	855	130	0.58	0.73
2	Kalupur	3.28	0.00	68.46	0.81	1	0.17	89.62	0.88	919	842	100	0.52	0.59
3	Dariapur	85.55	4.25	69.09	0.51	1	0.17	88.35	0.83	935	847	118	0.63	0.53
4	Shahpur	158.88	15.84	69.19	0.11	1	0.17	80.89	0.53	918	808	155	0.55	0.34
5	Raikhad	24.27	6.67	68.47	0.63	2	0.33	81.20	0.54	932	818	160	0.61	0.53
6	Jamalpur	43.07	13.35	69.46	0.39	3	0.50	84.07	0.66	930	816	121	0.45	0.50
7	Paldi	22.73	0.93	65.39	0.91	5	0.83	90.56	0.92	953	907	225	0.82	0.87
8	Vasna	33.47	5.25	65.31	0.80	0	0.00	81.14	0.54	927	826	231	0.65	0.50
9	Gandhigram	32.76	1.87	65.62	0.86	0	0.00	86.12	0.74	874	795	240	0.53	0.53
10	Navrangpura	54.51	2.56	66.96	0.73	2	0.33	85.25	0.71	940	856	211	0.81	0.64
11	Sardar Patel Stadium	39.22	5.87	64.86	0.80	2	0.33	86.45	0.75	878	804	155	0.35	0.56
12	Naranpura	29.38	2.66	66.36	0.81	0	0.00	92.61	1.00	923	885	208	0.67	0.62
13	Nava Vadaj	7.67	1.89	67.44	0.82	0	0.00	90.81	0.93	889	823	152	0.49	0.56
14	Juna Vadaj	87.92	14.77	65.18	0.49	2	0.33	75.73	0.32	866	700	219	0.42	0.39
15	Sabarmati	73.66	5.66	69.03	0.51	2	0.33	79.62	0.48	897	729	150	0.45	0.44
16	Dusheshwar	77.67	3.96	68.64	0.56	5	0.83	74.3	0.27	879	686	151	0.37	0.51
17	Madhupura	42.36	2.16	67.51	0.73	2	0.33	80.07	0.50	862	724	135	0.34	0.48
18	Girdharnagar	54.44	8.11	68.37	0.54	3	0.50	83.87	0.65	892	757	190	0.51	0.55
19	Asarwa	89.02	11.70	71.21	0.24	1	0.17	79.06	0.46	887	693	141	0.38	0.31
20	Naroda Road	153.94	9.51	69.46	0.24	2	0.33	78.81	0.45	869	677	153	0.37	0.35
21	Saraspur	31.97	8.78	68.28	0.57	2	0.33	80.6	0.52	895	739	194	0.53	0.49
22	Potalia	69.49	3.14	68.77	0.59	2	0.33	83.65	0.64	874	748	133	0.40	0.49
23	Kubernagar	45.60	10.82	69.85	0.42	0	0.00	79.83	0.49	849	690	82	0.18	0.27
24	Sardarnagar	83.09	1.58	67.84	0.64	0	0.00	79.8	0.49	902	771	135	0.44	0.39
25	Saijpur	51.03	1.60	69.44	0.62	1	0.17	80.4	0.51	871	698	107	0.20	0.38
26	Thakkarbapanagar	20.63	2.60	69.12	0.68	1	0.17	88.24	0.82	864	781	85	0.35	0.51
27	Naroda Muthia	39.92	0.87	68.88	0.69	4	0.67	84.89	0.69	876	775	116	0.38	0.61
28	Bapunagar	9.54	1.35	70.09	0.68	2	0.33	83.75	0.65	888	759	139	0.39	0.51
29	Rakhial	117.49	2.91	69.10	0.47	5	0.83	75.8	0.33	875	692	175	0.38	0.50
30	Gomtipur	74.39	1.14	68.93	0.61	5	0.83	78.85	0.45	892	732	161	0.53	0.60
31	Rajpur	56.13	0.22	69.21	0.65	4	0.67	75.42	0.31	863	683	161	0.49	0.53
32	Amraiwadi	107.61	3.81	67.09	0.58	1	0.17	80.38	0.51	834	657	140	0.23	0.37
33	Bhaipura Hatkeshwar	41.71	3.30	66.98	0.74	0	0.00	83.29	0.63	844	703	153	0.33	0.42
34	Nikol Road	60.98	2.61	67.54	0.68	1	0.17	85.68	0.72	849	743	112	0.28	0.46
35	Odhav	77.30	0.90	67.30	0.69	1	0.17	82.09	0.58	831	684	94	0.17	0.40
36	Khokhra Mahemdavad	9.44	0.88	68.04	0.80	6	1.00	89.43	0.87	921	842	190	0.81	0.87
37	Maninagar	17.07	7.77	68.07	0.64	3	0.50	86.72	0.76	925	857	167	0.60	0.63
38	Kakaria	43.64	11.25	67.99	0.51	1	0.17	80.49	0.51	907	761	188	0.51	0.43
39	Behrampura	127.99	5.78	67.23	0.49	2	0.33	67.64	0.00	890	676	211	0.46	0.32
40	Danilimda	32.38	4.56	69.44	0.60	3	0.50	77.72	0.40	906	783	131	0.48	0.50
41	Bagefirdaus	4.83	1.37	69.35	0.73	0	0.00	88.93	0.85	871	789	108	0.37	0.49
42	Vatva	36.68	0.18	67.77	0.77	2	0.33	79.27	0.47	847	690	113	0.24	0.45
43	Isanpur	11.04	0.56	67.48	0.83	1	0.17	85.86	0.73	867	774	134	0.36	0.52

Most Desired
Least Desired

Annexure

4. Ahmedabad Data

Datasets for Density Measures

	Ward	Physical Density			Amenity				Autonomy	
		Person/sq.km	Household/sq. km	Composite	% population served by sewerage	% of ward area with piped water supply	No. of dependent /solid waste collection point	Composite	Ratio of employed in ward and avg. of city	Composite
1	Khadia	39543.48	8502.90	0.48	98.0	98	8019	0.61	1.048	0.64
2	Kalupur	44930.88	8463.97	0.51	98.0	98	8019	0.61	0.988	0.34
3	Dariapur	85244.59	15564.86	1.00	98.0	98	8019	0.61	0.964	0.22
4	Shahpur	55976.79	10512.50	0.65	98.0	98	8019	0.61	0.971	0.26
5	Raikhad	34755.91	6543.55	0.38	98.0	98	8019	0.61	0.969	0.25
6	Jamalpur	66536.00	10823.00	0.72	98.0	98	8019	0.61	0.962	0.21
7	Paldi	12968.34	2755.19	0.12	116.6	95	4880	0.83	1.089	0.84
8	Vasna	18830.73	4017.64	0.20	116.6	95	4880	0.83	1.094	0.87
9	Gandhigram	10033.18	2085.50	0.08	116.6	95	4880	0.83	1.097	0.88
10	Navrangpura	8857.35	1841.91	0.07	116.6	95	4880	0.83	1.031	0.56
11	Sardar Patel Stadium	21951.20	4554.52	0.24	116.6	95	4880	0.83	1.121	1.00
12	Naranpura	23792.00	5332.57	0.28	116.6	95	4880	0.83	1.078	0.79
13	Nava Vadaj	30633.63	6480.72	0.36	116.6	95	4880	0.83	1.028	0.54
14	Juna Vadaj	19550.82	4013.86	0.21	116.6	95	4880	0.83	1.073	0.76
15	Sabarmati	15160.58	3012.45	0.14	116.6	95	4880	0.83	0.939	0.10
16	Dusheshwar	27540.89	4993.93	0.29	98.0	98	8019	0.61	1.001	0.40
17	Madhupura	16418.14	2994.65	0.15	98.0	98	8019	0.61	1.018	0.49
18	Girdharnagar	29312.78	5500.44	0.32	98.0	98	8019	0.61	0.975	0.27
19	Asarwa	36949.32	6526.71	0.40	95.6	80	5605	0.20	0.919	0.00
20	Naroda Road	47857.71	8563.43	0.53	95.6	80	5605	0.20	0.951	0.15
21	Saraspur	42042.60	7730.18	0.47	95.6	80	5605	0.20	0.971	0.26
22	Potalia	19869.38	3756.79	0.20	95.6	80	5605	0.20	0.975	0.28
23	Kubernagar	37595.28	7219.31	0.42	95.6	80	5605	0.20	0.952	0.16
24	Sardarnagar	25941.04	4954.29	0.28	95.6	80	5605	0.20	1.002	0.41
25	Saijpur	37040.47	7326.05	0.43	95.6	80	5605	0.20	0.939	0.09
26	Thakkarbapanagar	32620.96	6379.04	0.37	95.6	80	5605	0.20	0.979	0.30
27	Naroda Muthia	8606.03	1795.71	0.06	95.6	80	5605	0.20	0.973	0.27
28	Bapunagar	39487.28	7035.53	0.43	83.0	80	3858	0.20	0.947	0.14
29	Rakhial	24546.08	4141.83	0.24	83.0	80	3858	0.20	0.942	0.11
30	Gomtipur	36423.40	6520.21	0.39	83.0	80	3858	0.20	0.955	0.18
31	Rajpur	23579.35	4072.90	0.23	83.0	80	3858	0.20	0.930	0.05
32	Amraiwadi	35753.74	7261.68	0.42	83.0	80	3858	0.20	1.027	0.53
33	Bhaipura Hatkeshwar	61476.05	12967.07	0.77	83.0	80	3858	0.20	1.038	0.59
34	Nikol Road	28921.63	5744.71	0.32	83.0	80	3858	0.20	1.001	0.40
35	Odhav	15338.76	3306.63	0.16	83.0	80	3858	0.20	1.026	0.53
36	Khokhra Mahemdavad	31393.42	6529.39	0.36	83.0	80	3858	0.20	1.008	0.44
37	Maninagar	27129.63	5633.33	0.31	90.0	80	4503	0.29	1.010	0.45
38	Kakaria	20149.86	3741.16	0.20	90.0	80	4503	0.29	1.015	0.48
39	Behrampura	8934.10	1630.18	0.06	90.0	80	4503	0.29	1.008	0.44
40	Danilimda	21214.04	3874.81	0.21	90.0	80	4503	0.29	0.976	0.28
41	Bagefirdaus	19062.19	3922.66	0.20	90.0	80	4503	0.29	0.982	0.31
42	Vatva	3708.87	811.40	0.00	90.0	80	4503	0.29	1.012	0.46
43	Isanpur	9094.09	1908.78	0.07	90.0	80	4503	0.29	1.019	0.50

Highest
Lowest

Annexure

5. Tokyo Data

Datasets for Development Indicators

	Ward	Economic Equity			Social Equity			Good Governance		Environment				Composite DI
		% of ward population unemployed	% of total households assisted by district	Composite	% of females in total employed persons	Senior citizen population / working	Composite	crime / population	Composite	Complaints of Air pollution/ Household	Complaints of Noises/ Household	Complaints of Vibration/ Household	Composite	
1	Chiyoda-*ku*	1.51	1.73	0.952	43.82	0.41	0.51	0.130	0.00	0.0012	0.0030	0.0006	0.000	0.37
2	Chuo-ku	1.92	1.14	0.927	45.25	0.34	0.92	0.045	0.73	0.0003	0.0009	0.0002	0.721	0.83
3	Minato-*ku*	1.65	1.63	0.936	45.17	0.43	0.57	0.048	0.71	0.0009	0.0023	0.0004	0.309	0.63
4	Shinjuku-*ku*	3.26	3.79	0.480	43.36	0.39	0.57	0.037	0.80	0.0001	0.0005	0.0001	0.897	0.69
5	Bunkyo-*ku*	2.35	1.39	0.832	44.05	0.37	0.69	0.016	0.99	0.0001	0.0006	0.0002	0.829	0.83
6	Taito-*ku*	3.42	7.36	0.164	43.26	0.44	0.34	0.041	0.77	0.0001	0.0010	0.0001	0.814	0.52
7	Sumida-*ku*	3.64	3.76	0.416	42.46	0.38	0.54	0.022	0.94	0.0003	0.0010	0.0002	0.742	0.66
8	Koto-*ku*	3.45	2.41	0.556	41.54	0.34	0.62	0.017	0.97	0.0002	0.0007	0.0001	0.854	0.75
9	Shinagawa-*ku*	2.62	1.83	0.749	43.28	0.36	0.68	0.014	1.00	0.0002	0.0006	0.0001	0.851	0.82
10	Meguro-*ku*	2.09	1.49	0.870	44.87	0.37	0.77	0.015	1.00	0.0002	0.0011	0.0002	0.752	0.85
11	Ota-*ku*	2.50	2.68	0.702	40.99	0.36	0.49	0.014	1.00	0.0001	0.0002	0.0001	0.961	0.79
12	Setagaya-*ku*	2.03	1.13	0.908	43.21	0.37	0.62	0.018	0.97	0.0002	0.0003	0.0001	0.876	0.85
13	Shibuya-*ku*	2.33	1.68	0.812	44.81	0.39	0.67	0.050	0.69	0.0001	0.0006	0.0001	0.878	0.76
14	Nakano-*ku*	3.09	2.47	0.614	43.03	0.43	0.38	0.019	0.96	0.0002	0.0006	0.0001	0.859	0.70
15	Suginami-*ku*	2.45	1.55	0.802	43.77	0.38	0.62	0.016	0.98	0.0002	0.0005	0.0001	0.864	0.82
16	Toshima-*ku*	2.57	2.71	0.686	43.13	0.41	0.47	0.039	0.79	0.0002	0.0009	0.0002	0.769	0.68
17	Kita-*ku*	4.36	3.54	0.307	42.24	0.45	0.24	0.019	0.96	0.0001	0.0001	0.0000	0.999	0.63
18	Arakawa-*ku*	4.08	4.27	0.296	42.43	0.43	0.33	0.019	0.96	0.0002	0.0009	0.0003	0.727	0.58
19	Itabashi-*ku*	3.23	3.45	0.510	42.09	0.37	0.51	0.018	0.97	0.0002	0.0004	0.0001	0.869	0.72
20	Nerima-*ku*	2.12	2.61	0.774	40.83	0.44	0.14	0.016	0.98	0.0001	0.0002	0.0000	0.971	0.72
21	Adachi-*ku*	3.85	4.42	0.324	40.34	0.40	0.27	0.022	0.93	0.0004	0.0004	0.0001	0.839	0.59
22	Katsushika-*ku*	3.83	3.27	0.421	41.01	0.40	0.34	0.018	0.97	0.0005	0.0006	0.0001	0.787	0.63
23	Edogawa-*ku*	2.86	2.68	0.638	39.45	0.32	0.50	0.021	0.94	0.0003	0.0006	0.0001	0.820	0.73

	Most Desired
	Least Desired

Annexure

6. Tokyo Data

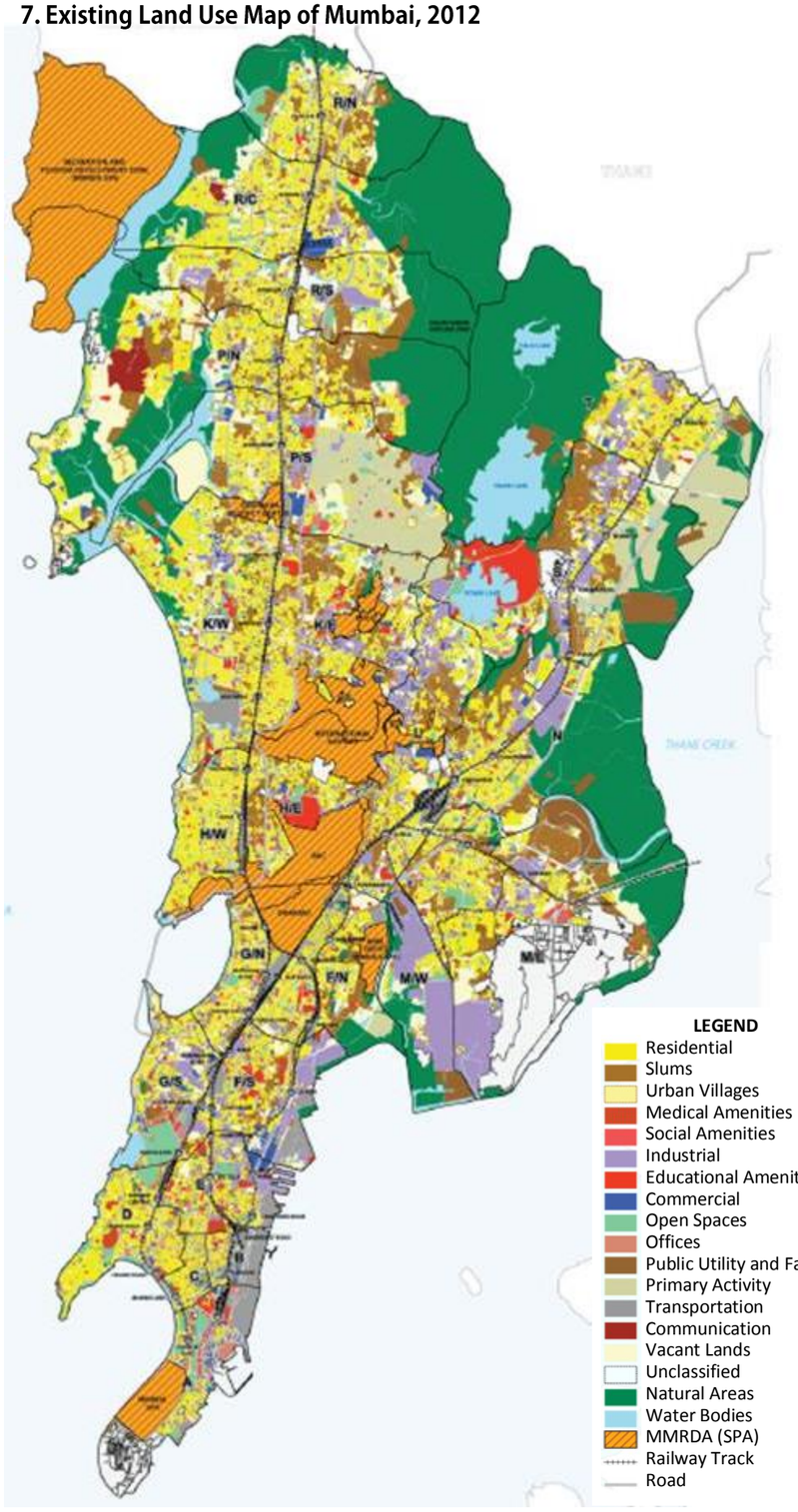
Datasets for Density Measures

Ward		Physical Density			Intensity				Amenity		Autonomy		Frequency	
		Households/ sq.km	People / sq.km	Composite	Gross built density per Ha	Net construction density per Ha	Net land coverage ratio %	Composite	Mixed use sq.m/person	Composite	People / establishments	Composite	Daytime density minus nightime density	Composite
1	Chiyoda-*ku*	1906	3589	0.00	11.4	19.5	49.8	0.062	3.58	0.45	24.60	1.00	69733.59	1
2	Chuo-ku	5098	9694	0.37	17.8	42.9	62.2	0.471	4.45	0.70	16.31	0.54	54139.21	0.78
3	Minato-*ku*	4682	9138	0.33	14.6	25.1	49.4	0.128	3.38	0.39	19.68	0.73	35555.95	0.53
4	Shinjuku-*ku*	8634	16770	0.78	28.1	41.6	53.2	0.443	3.02	0.29	16.22	0.54	25577.95	0.39
5	Bunkyo-*ku*	8182	16767	0.76	33.6	48.4	55.0	0.576	3.07	0.31	11.92	0.30	12967.73	0.21
6	Taito-*ku*	8202	16388	0.75	40	72.7	67.6	0.993	5.54	1.00	8.74	0.12	13888.29	0.23
7	Sumida-*ku*	7946	16813	0.74	35.1	64.3	60.3	0.773	4.61	0.74	8.68	0.12	2285.24	0.07
8	Koto-*ku*	4881	10657	0.38	13.8	31.4	48.1	0.138	1.98	0.00	13.00	0.36	1769.59	0.06
9	Shinagawa-*ku*	7702	15245	0.68	25.8	45.2	51.2	0.409	2.36	0.11	13.90	0.41	7048.68	0.13
10	Meguro-*ku*	9072	17964	0.84	34.5	46.8	50.3	0.505	2.87	0.25	10.77	0.23	1535.44	0.06
11	Ota-*ku*	5410	11195	0.43	21	43.7	48.7	0.307	2.66	0.19	9.26	0.15	-114.67	0.03
12	Setagaya-*ku*	7111	14483	0.63	27.9	42.4	45.7	0.332	2.09	0.03	8.88	0.13	-1451.10	0.01
13	Shibuya-*ku*	7480	13457	0.62	25.2	36.8	50.2	0.334	5.14	0.89	14.17	0.42	22734.81	0.35
14	Nakano-*ku*	10789	19925	1.00	40.1	55.9	53.3	0.671	2.55	0.16	8.05	0.08	-1587.94	0.01
15	Suginami-*ku*	8153	15538	0.72	32.8	47.6	48.3	0.460	2.25	0.08	7.85	0.07	-2445.71	0.00
16	Toshima-*ku*	10285	19261	0.95	40.6	59.8	57.4	0.764	2.93	0.27	12.19	0.31	11170.95	0.19
17	Kita-*ku*	7744	16047	0.71	31.3	55.2	51.0	0.532	2.54	0.16	8.42	0.10	-1118.41	0.02
18	Arakawa-*ku*	8326	18746	0.83	40	70.1	59.6	0.855	3.38	0.39	7.11	0.03	-700.20	0.02
19	Itabashi-*ku*	7784	16260	0.72	27.2	45.4	49.9	0.407	2.36	0.11	9.23	0.15	-1596.95	0.01
20	Nerima-*ku*	6455	14376	0.59	27.9	46.5	47.5	0.385	2.22	0.07	7.73	0.06	-2347.57	0.00
21	Adachi-*ku*	5260	11744	0.44	27.2	51.6	47.0	0.401	3.14	0.33	7.23	0.04	-1563.74	0.01
22	Katsushika-*ku*	5504	12213	0.47	30	57.8	51.3	0.538	2.97	0.28	6.57	0.00	-2350.79	0.00
23	Edogawa-*ku*	5774	13142	0.51	24.8	53.6	51.6	0.456	2.15	0.05	7.66	0.06	-2388.73	0.00

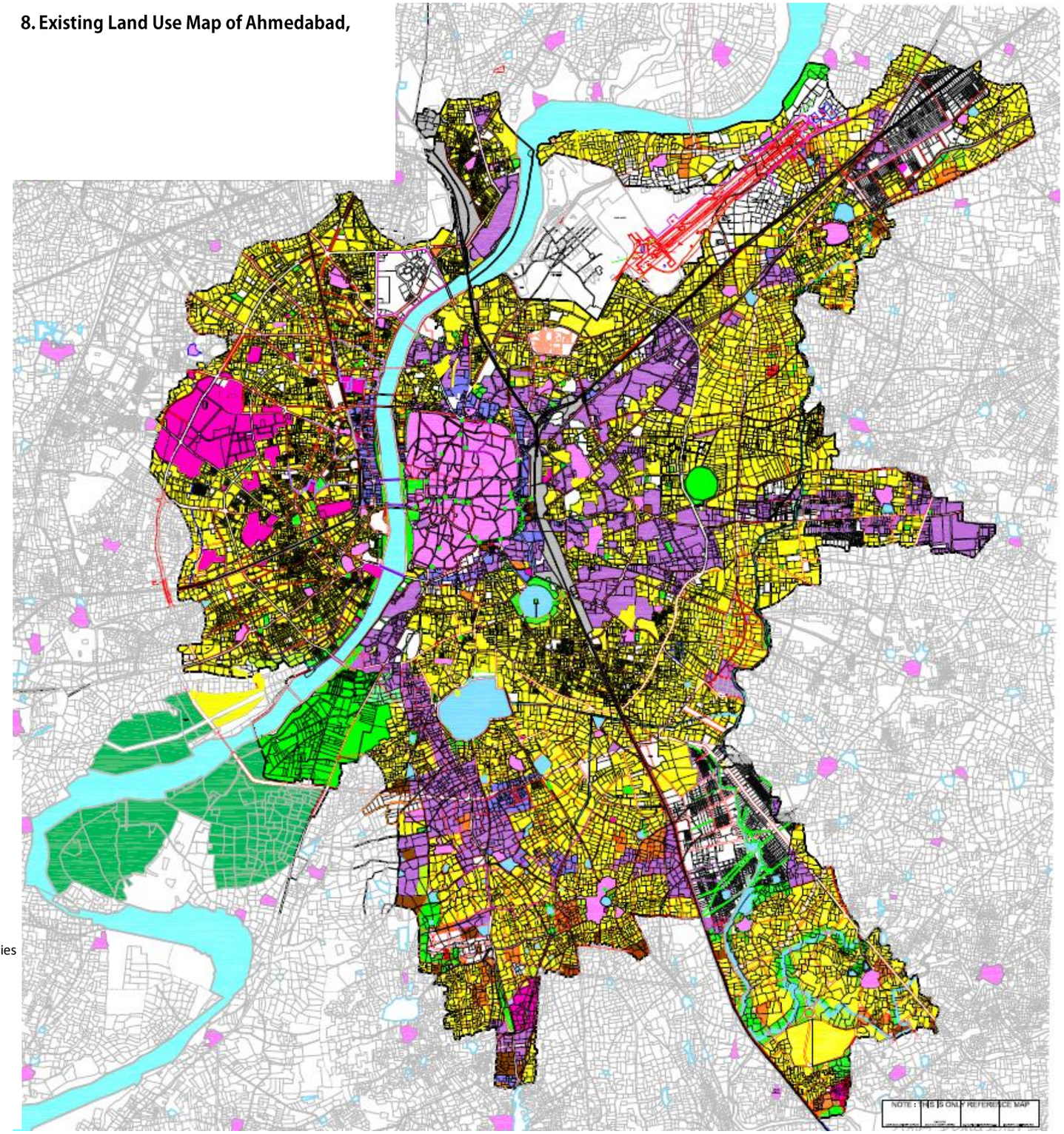
	Highest
	Lowest

Annexure

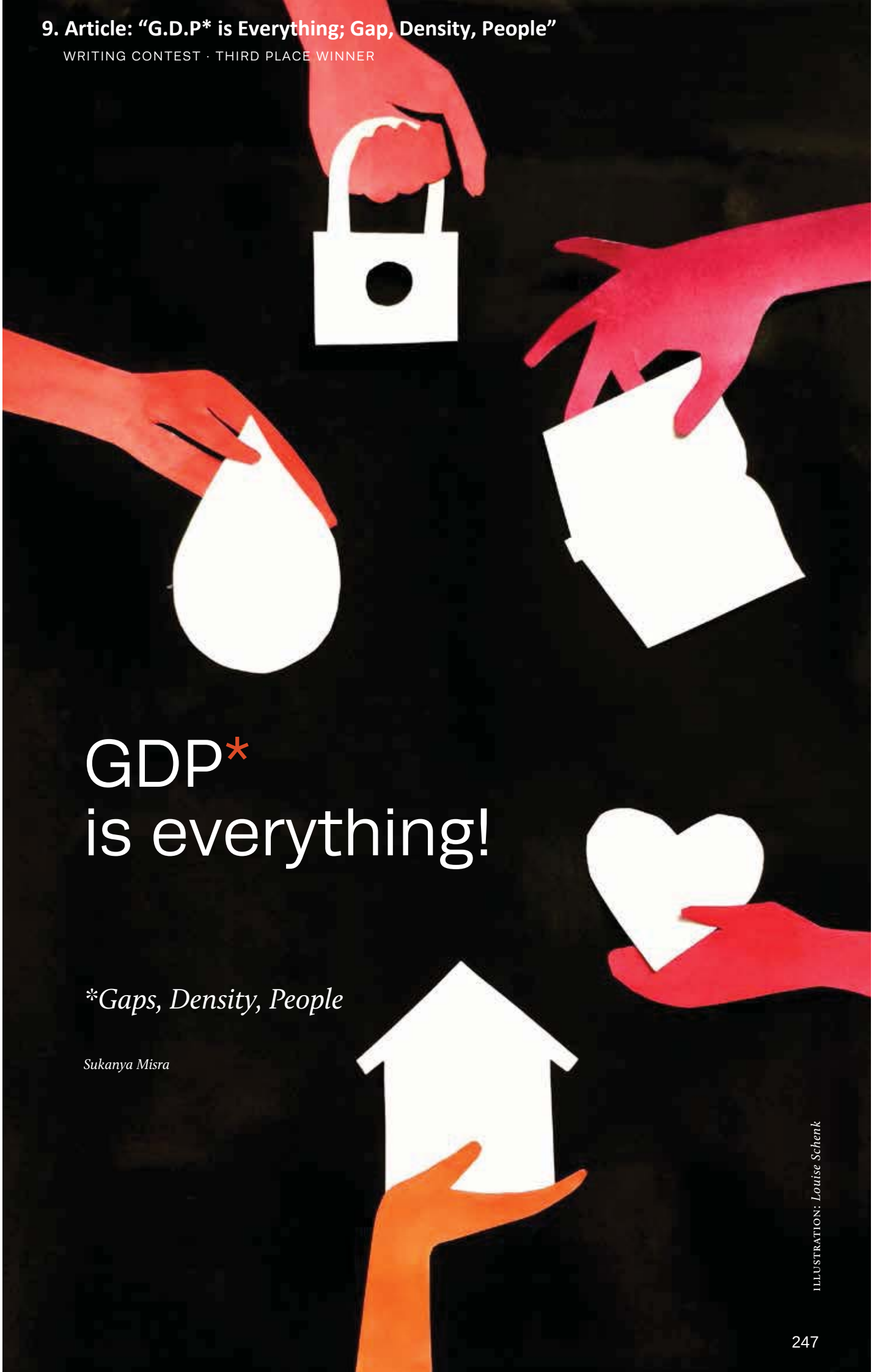
7. Existing Land Use Map of Mumbai, 2012



8. Existing Land Use Map of Ahmedabad,



Annexure



GDP* is everything!

**Gaps, Density, People*

Sukanya Misra

ILLUSTRATION: *Louise Schenk*

Kavya is the daughter of a middle class family living in south India. She is 14 years old and is an average student. Her parents started saving money from the day she was born, for the dowry they will pay to the groom's family when she gets married. They have her best interests in heart and love her very much, which is why they have already started looking for a suitable match for her in a respected, wealthy, educated family. They have facilitated her training in classical music and dance from a very young age and she has learnt to cook all the traditional delicacies of her culture, not for vocational purposes, but because these are the qualities sought in matrimonial prospects. They have never encouraged her to study. Her mother believes that if women acquire too much knowledge, it destroys the balance of a family.

Kavya has heard the course of her life laid down for her many times and has grown up accepting it. She has never wondered what she might want to do if allowed the chance of higher studies or a job. She does not dare to dream and feels safe in the confines of her domestic existence. She has great admiration for her elder brother Hari. Hari is 20 years old. Their parents started saving money from the day he was born, to pay for his education. They want Hari to become a software engineer and study in the US. Kavya admires how intelligent he is, the conviction with which he states his opinions, and the many important books and exams that take up all of his time. Their father owns a small textile business which has recently been doing very well as more and more foreign clothing brands are buying textiles from India. He is a satisfied man and takes great pride in the fact that he is a part of the industry that contributes the second largest share (after agriculture) to the growing Indian economy. He foresees the IT sector to be largest GDP contributor in the future of India and lovingly laughs with his son about how their family represents the backbone of India's economy. Kavya has never felt the need of money. She has however felt the gap in the way it is spent. Although she tells herself she should be thankful for having all of life's necessities, she sometimes cannot help but wish that she too could have a college degree and go on to be a part of that alien concept her father and brother talk about; India's GDP.

Sankalp is a 13-year-old boy who lives with his parents in the western state of Maharashtra. He is autistic, which means that he has difficulty in communicating with people, even his parents. Sankalp is home-schooled since there are no learning facilities for children with special needs where he lives, and regular schools refuse to grant him admission. He has always been treated differently, rejected by society, other children and educators. His parents, however, have strived to give him a normal childhood. They noticed his deep inclination for music and asked a close family friend with musical training to teach him some songs in their mother tongue. Sankalp has grown extremely fond of his music teacher. So much so, that he calls her his "other mother." When he sings, he does so in perfect pitch, remembers all the words, does not stutter and does not fidget or grow restless, which are otherwise his constant traits. He listens to music too, and requests for his favourite songs be taught to him. Through his music, his parents have discovered the hidden personality, depth, emotions, sensibility, maturity and intense pain that Sankalp has no other way of communicating. For the first time in 13 years, his parents can feel his response; for the first time in 13 years, Sankalp feels confident, aspiring to become a professional singer. Through sensitive, creative and inclusive education suited specifically for Sankalp and for each individual child, the gaps—in the capabilities afforded to different genders, differently-abled children, minorities by religion or caste, different economic backgrounds—can be bridged, to create individuals who can better serve the nation and be contributors in its GDP.

> "Gaps created between the genders, the differently-abled, and on the basis of religion, caste, linguistics, et cetera, must be identified, and sensitive bridging of these gaps will bring about better development."

If Kavya's family and Sankalp's family are considered to be two different countries, which country seems to be at a more advanced stage of development? Both families have similar net earnings, which enable them to provide for the basic amenities and facilities required for comfortable living. Their economic condition is in no way hinder-

ing individual members of the family. However, the well-being of the individual family members varies greatly. Gaps created between the genders, the differently-abled, and on the basis of religion, caste, linguistics, et cetera, must be identified, and sensitive bridging of these gaps will bring about better development. It is important for nations to measure and assess these gaps for their development. The ways in which resources (economic and otherwise) are utilized must be measured; the net earnings alone indicate nothing.

"Gaps exist in affluent areas as well as poor areas, while some of the poor ones... actually provide a larger contribution to the overall economy than that which can be understood from looking at GDP."

A.T.C Nagar is an affluent gated community in Delhi. Sugata Sen is a warm hearted resident of A.T.C Nagar who enjoys the company of family and friends. He owns a printing business, which has supported his family and his children's education. He owns a three-storied, white palatial house located at the corner, overlooking the community playground. A.T.C Nagar is a close-knit community and there are many social gatherings every weekend, as well as charity events hosted by its prosperous residents. The colony has a very high average income and by economic measures, it has no insecurities. However, economic measures cannot gauge the actual situation of the residents of this area. Sugata Sen loves it when his brother's family visits him from another city. Yet, he lives in a part of Delhi that suffers from acute water shortages. He has to buy drinking water and water for domestic use from a private water tanker at very high costs. When his brother's family visits, he worries that he will not be able to acquire double the amount of water even in lieu of high costs and often has to choose between bathing and running the washing machine, even during the scorching Delhi summers. The density of infrastructure networks such as water supply, sanitation, electricity, et cetera, and the percentage of households covered by adequate levels of these services is therefore an extremely important measure in understanding the underlying welfare of the inhabitants of any area.

There are a few scales of density that are important for human life. A person needs a place to live which affords him appropriate privacy. Therefore, residential room density is important. On a slightly larger scale, a person needs an adequate balance of built-up areas and open spaces in their neighbourhood, so as to allow him to enjoy sunlight and fresh air. The built intensity of a place therefore plays an important part in a person's well-being. Furthermore, it is seen that a person living in a slum and one living in a high-rise apartment building in the downtown area of a large city may both have access to the same amount of personal living space but the latter has a much higher level of well-being due to the presence of physical amenities such as clean water, sanitation, electricity, telephone connection, solid waste disposal system and a structurally sound shelter. In the absence or inadequacy of these, the slum dweller is forced to live among filth, travel long distances to carry water back to their homes, defecate in the open and be in constant danger of leaks or floods. The density of amenities is therefore the most important density measure for well-being and can provide much insight into a community's well-being.

Another very important factor is the level of autonomy, or job density of an area. Vimla is a resident of the famous Dharavi slum in Mumbai. She lives in a tiny hut with her husband and three daughters. They do not have access to piped water and have to cross the railway line illegally every day to get water from a public water tap and carry it back to their home. She sends her daughters to school but is constantly worried about their safety, as crime against women and human trafficking are rampant in the area. She does not allow her children to leave the premises of their home after

6 o'clock in the evening. Vimla and her family had lost everything in the heavy floods that decimated the city in 2005, and had to borrow money to rebuild their lives, thus living with the added weight of debt. In spite of all this, Vimla has been a resident of Dharavi all her life and would like nothing more than the government to allocate a safe living tenement for her family within the locality of Dharavi. She works as a maid in an affluent area nearby. Her husband is a metal worker in an industrial unit run within the slum.

Vimla, and many like her, say that they would rather live in slum conditions in an area like Dharavi than live in a well-serviced apartment in the outskirts of Mumbai, where it is very difficult to find a job. Dharavi has a very high level of autonomy—that is, job density. As it is located in-between the two main railway lines and in the heart of Mumbai, residents find it very easy to get jobs in the area. Many small scale industries, like the one in which Vimla's husband works, also thrive in Dharavi and manufacture products such as machine parts, embroidered garments, export quality suitcases, second hand and assembled electronics and much more. The annual turnover of the business of this area is estimated to be over $650 million. Many of these industries are informal, and so do not directly count towards the city's GDP, but are responsible for supporting the formal economic sector. The job density of the area is what keeps people here, and supports the financial capital of India.

Lalita is also the resident of a slum in Mumbai. She moved to Mumbai 10 years ago from a village, after marriage. Most of the other inhabitants in her slum are also from the same rural area as she, and they are a close-knit community. After moving to Mumbai, she had found her alien urban environment to be frightening. However, with the help of the other women, she learned the ways of the city. Over the years, with the support of a non-governmental organization (NGO), the women living in the slum formed a self-help group, which pooled together the group's savings to, with the help of a microfinance loan, build a day-care centre. The women take turns supervising the infants in the community while the others go to work. The centre is the only structurally stable construction in the slum, and also serves as a maternity ward, where the NGO has arranged for a nurse. This has ensured hygienic childbirth practices, resulting in increased survival rates and better health for mothers and their newborn children. It has also helped educate the women about nutrition, vaccination and family planning, leading to a marked increase in the overall health and well-being of the children of the area, a drop in number of pregnancies and an increased interest in the education of the now-smaller number of children in each family. In addition, the structure served as a shelter during the 2005 floods, while most of the huts were washed away. It is is a physical symbol of the social integration of the slum dwellers, and how a network of people who would have no power individually can help to strengthen a community and be the drivers of its development.

The stories of Kavya, Sankalp, Sugata, Vimla and Lalita show that insecurities exist in every economic stratum. Gaps exist in affluent areas as well as poor areas, while some of the poor ones, such as Dharavi, actually provide a larger contribution to the overall economy than that which can be understood from looking at GDP. Although gaps in capabilities may be worse for the poor, they also exist in higher economic classes, and these gaps must be identified at a grassroots level for sensitive development to take place, development that would be able to ensure equal capability for all. Once gaps have been identified, measurement of GDP will not benefit the filling of these gaps. Instead, the measurement of various layers of density must be done, such as amenity density, job density, built environment intensity and room density, which would provide a better picture of the existing physical, as well as social issues. Finally, having identified the *gaps* and measured the *densities*, the development action must be carried out through a network of local *people*.

The GDP of a nation cannot hope to capture the level of well-being of its people. It is a macroscopic measure aggregating large populations with large variations into a single mean without consideration for the large deviations from this mean. It does not measure the diverse socio–cultural issues that are the real development concerns of a nation. The amount of money that one is in possession of does not determine the way in which one spends that money. We must instead directly measure the ways in which we spend money: outcome variables that assess development levels, such as identified gaps and layers of various existing densities, will be a more accurate indicator. It is time to focus on a micro scale system of measurement, sensitive to the various socio–cultural layers, and for that, G.D.P., the Gaps, Density, and People, are everything.

Disclaimer: All characters appearing in this work are fictitious. Any resemblance to real persons, living or dead exists because issues related to their capability deprivation have not been effectively addressed!

List of Publications

Refereed Journal Papers

1. **A Methodology for studying the Urban Density characteristics corresponding to varying Human Security and its application on Mumbai, Ahmedabad and Tokyo**, Misra and Monnai, Journal of Architecture and Planning, Transactions of Architectural Institute of Japan, Vol. 79(2014),No. 703, pp. 1933-1943, 2014.9

2. **Investigating the Effects of Urban Density on Human Security in Mumbai**, Misra and Monnai, Journal of Architecture and Planning, Transactions of Architectural Institute of Japan, Vol. 79,No. 696, pp.393-403, 2014.2

3. **Study on Measures of Urban Density and Human Security for Sustainable Urban Form: Case Study of Mumbai**, Misra and Monnai, Journal of Architecture and Planning, Transactions of Architectural Institute of Japan, Vol. 78, No. 685, pp.603-613, 2013.3

Conference Papers (Peer Reviewed)

1. **Urban Density Measures addressing disaster vulnerability in developing countries: Case Study of Mumbai**, Misra and Monnai, 9th Annual International Conference, International Institute for Infrastructure Renewal and Reconstruction, Queensland Institute of Technology, Brisbane, Australia, July 8th – 11th, 2013

2. **An Integrated Approach to Brownfield Re-Design: Case Study of Ahmedabad Textile Mill Areas**, Misra, Sengupta and Monnai, Proceedings of Design Symposium 2012, pp. 415 – 422, Kyoto University, October 16th - 17th, 2012

Conference Papers

1. **A methodology for studying the urban density characteristics corresponding to varying human security and its application on Mumbai, Ahmedabad and Tokyo**, Misra and Monnai, Proceedings of AIJ Kinki Branch Conference 2014

2. **Relationship between Density Measures and Composite Development Indicator: Exploring the effects of Urban Density on Human Security in Mumbai – Part 1**, Misra and Monnai, Annual AIJ Conference, Hokkaido University, Sapporo, Japan,29th August-1st September, 2013

3. **Effects of Crowding on Human Security using Cluster Analysis: Exploring the effects of Urban Density on Human Security in Mumbai – Part 2**, Misra, Monnai and Araki, Annual AIJ Conference, Hokkaido University, Sapporo, Japan, 29th August-1st September, 2013

4. **Exploring the effects of urban density on human security in Mumbai using ward wise census data**, Misra and Monnai, Proceedings of AIJ Kinki Branch Conference 2013

5. **Measuring Urban Density: An analytical review: Formulating Indicators towards Sustainable Urban Densities - Part 1**, Misra and Monnai, Annual AIJ Conference 2012, Nagoya University, Japan, 12th – 14th September, 2012

6. **Measuring Urban Development at the Micro level: Case Study of Mumbai, India: Formulating Indicators towards Sustainable Urban Densities - Part 2**, Misra, Monnai and Yamashita, Annual AIJ Conference 2012, Nagoya University, Japan,12th – 14th September, 2012

7. **Formulating measurable Indicators for assessing Urban Density and Quality of Development in Mumbai and Ahmedabad**, Misra and Monnai, Proceedings of AIJ Kinki Branch Conference 2012

Other Published Work

1. Won 3rd prize in **IHDP** (International Human Dimensions Programme on Global Environmental Change, **United Nations University**) **International Writing Contest** "Beyond G.D.P." Article published in spring 2014 issue of "Dimensions" magazine (Access: http://www.ihdp.unu.edu/article/read/gdp-is-everything)

2. 2nd prize in XXXVI IAHS **World Congress on Housing Science** paper presentation competition, 2008